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TOXICOLOGY.—*Observations on toxic marine algae.*[1]

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Toxic substances in fresh-water algae have been reported by many authors (Deem and Thorp, 1939; Fitch et al., 1934; Shelubsky, 1951; Steyn, 1943; Wheeler, Lackey, and Schott, 1942; and others), but there do not appear to be any reports of toxic marine algae. The spotty geographical distribution of fish poisoning, the presence of algae in the stomach content of many poisonous fish, and the high correlation between toxic stomach contents and toxic fish (Dawson, Aleem, and Halstead, 1955) have prompted this study of marine algae.

Materials and methods.—Material was obtained from Corona Del Mar, Calif., and Palmyra Island, which is 960 nautical miles south by west of Honolulu. The algae were frozen shortly after collection and were kept frozen until used. They were identified through the kindness of Dr. Yale Dawson of the University of Southern California. Algal extracts were prepared routinely by blending frozen or equivalent amounts of dried algae with equal amounts of distilled water in a Waring Blendor for 20 minutes, and then centrifuging at 2,800 RPM for one hour. The supernatant was drawn off and stored in extract bottles. Solidification of some of the extracts due to their agar content was eliminated by drying and powdering the algae in a mortar before extracting them.

A more concentrated and purified extract was obtained from algae that had been disintegrated in a food grinder, by extraction with boiling water using a ratio of algae to water of 2:5. It was centrifuged for 30 minutes and the supernatant washed four times with chloroform which removed fats and pigments to some extent. This was then distilled to dryness and reconstituted in a small amount of distilled water for injection.

The toxicity of the extracts was tested by intraperitoneal injection of 1.0 ml volumes into weanling mice of the California Caviary strain No. 1 (CC_1), weight 15–23 g. All routine screening was done by injecting one or two groups of four mice each, and the results were confirmed in a number of representative cases by large-scale injections of 20 mice. Intraperitoneal injection results were confirmed in some cases by stomach-tubing mice.

The injected mice were placed under observation for 36 hours for the development of symptoms. If one or more of the mice died within an hour after injection the extract was classified as strongly toxic. It was considered moderately toxic if one or more died within 36 hours, and weakly toxic if they displayed two or more of the following symptoms: lacrymation, ruffed hair, diarrhea, dyspnea, or weakness.

Large-scale control injections were run using distilled water, tap water, and sea water. Lettuce extracts comparable to the algal extracts were tested to eliminate the possibility that plant pigments and proteins generally are toxic. All of these tests were negative. A strongly toxic extract was autoclaved and injected aseptically with results identical with untreated extracts.

Results: Routine survey.—A number of samples of algae consisting of both single and inseparably mixed species from Palmyra Island and Corona Del Mar have been tested by the routine screening procedure. The results are shown in Table 1

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and are based on two or more separate tests which gave comparable results.

In addition a number of similar mixtures of algae found in the stomach and intestine of fish collected at Palmyra Island were tested by the routine screening procedure. The results are shown in Table 2. The toxicities of portions of the fish as determined by the methods of Dawson, Aleem, and Halstead (1955) are also summarized in this table.

TABLE 1.—RESULTS OF ROUTINE SURVEY OF TOXICITY OF EXTRACTS OF PALMYRA AND CALIFORNIA ALGAE

Palmyra species	Toxicity
Lyngbya majuscula Gomont, with some *Bryopsis pennata* var. *secunda* (Harvey) Collins and Hervey	MT
Boodlea composita (Harvey) Brand, and *Caulerpa serrulata* (Forskål) Agardh, emend. Borgesen	MT
Turbinaria ornata (Agardh) Kutzing, with epiphytic *Jania tenella* Kützing. Also some *Ceramium masonii* Dawson, *Bryopsis pennata* var. *secunda* (Harvey) Collins and Hervey, and *Jania capillacea* Harvey. MAINLY *Turbinaria*	MT
Turbinaria ornata (Agardh) Kützing, with epiphytic *Jania tenella* Kützing. Also some *Ceramium masonii* Dawson, *Bryopsis pennata* var. *secunda* (Harvey) Collins and Hervey, and *Jania capillacea* Harvey. NOT MUCH *Turbinaria*	WT
Enteromorpha sp. apparently near *E. kylinii* Bliding. Absolute identification impossible	WT
Hormothamnion solutum Bornet and Flahault, and some *Centroceras clavulatum* (Agardh) Montagne	WT
Corona Del Mar, Calif. Species	**Toxicity**
Lithothrix aspergillus J. E. Gray	NT
Macrocystis pyrifera Harvey	MT
Gelidium cartilagineum var. *robustum* Agardh	MT
Pelvetia fastigiata Gardner	MT
Hesperophycus harveyanus Gardner	MT
Egregia laevigata Setchell	MT
Corallina officinalis var. *chilenus* (Harvey) Kützing	NT

Abbreviations: NT = Non-Toxic, WT = Weakly Toxic, MT = Moderately Toxic.

Large-scale tests.—The results of large-scale confirmatory tests with 20 mice using both toxic and nontoxic extracts are given in Table 3.

Concentration.—The greater toxicity of the more purified concentrated extract prepared as described previously is shown in Table 4. These results were obtained using four or more mice to test each extract.

Properties of toxin.—A number of the physical and chemical properties of the toxic materials have been observed, particularly on extracts of *Pelvetia fastigiata* Gardner.

The toxin(s) of *Pelvetia* is readily soluble in water but less soluble in ethanol, methanol, chloroform and ether. It is not destroyed by heating at 100° C. for one hour or by normal autoclaving. Freezing and thawing of aqueous extracts over a period of time tends to result in a gradual loss of toxicity. The ash of toxic extracts is not toxic. Tests for the presence of traces of arsenic, which may occur in marine algae (Read and How, 1927), were negative.

Deproteinization of extracts by boiling results in no loss of toxicity. The toxin(s) diffuses through a cellophane dialyzing membrane and is readily absorbed on activated charcoal.

Discussion.—These data appear to constitute definite evidence of the existence of one or more organic substances toxic to mice in marine algae.

TABLE 2.—TOXICITY OF PALMYRA FISH AND ALGAE IN THEIR INTESTINAL CONTENTS

Fish species	Extract No.	Part of fish	Toxicity Rating	Algae in intestinal contents
Acanthurus fuliginosus Lesson	R 663	M, L, I, IC	NT WT	*Lyngbya majuscula* Gomont and *Jania*
" " "	R 664	M, I, L, IC	NT MT	" " " " "
" " "	R 666	M, L, I, IC	MT NT	" " " " "
" " "	R 668	M, L, I, IC	MT	" " " " "
Chaetodon auriga Forskål	R 1051	M, V IC	NT MT	*Lyngbya majuscula* Gomont
Abudefduf septemfasciatus Cuvier	R 1065	M, V IC	NT MT	*Lyngbya majuscula* Gomont and *Bryopsis pennata* var. *secunda* (Harvey) Collins and Hervey
Abudefduf sordidus Forskål	R 895	M V IC	NT WT NT	*Bryopsis pennata* var. *secunda* (Harvey) Collins and Hervey and *Lyngbya majuscula* Gomont
Arothron hispidus Linnaeus	R 697	M, L, G I, IC, S	ST ST	*Caulerpa serrulata* (Forskål) Agardh, emend. Börgesen and Lyngbya

Abbreviations: M = Muscle, L = Liver, G = Gonads, I = Intestines, V = Viscera, IC = Intestinal contents, S = Skin, NT = Nontoxic, WT = Weakly toxic, MT = Moderately toxic, ST = Strongly toxic.

There is reason to believe that this indicates they may be toxic to other animals and man.

The simple properties of the toxic material(s) suggest some resemblance to the toxin(s) present in fresh water algae (Shelubsky, 1951). There is also some similarity to the toxins of certain toxic fish (Halstead and Bunker, 1954; Halstead and Ralls, 1954). As Table 2 shows, toxic algae occur in the intestinal contents of fish, other parts of which may be toxic. Much further investigation is required to determine whether this has any significance. Dawson, Aleem, and Halstead (1955) present additional data and discussion bearing on this problem.

TABLE 3.—RESULTS OF LARGE-SCALE TOXICITY TESTS OF EXTRACTS OF PALMYRA AND CALIFORNIA ALGAE

Species	Deaths (%)	Average death time (hours)
PALMYRA ISLAND:		
Boodlea composita (Harvey) Brand and *Caulerpa serrulata* (Forskål) Agardh, emend. Börgesen	100	19
Hermothamnion solutum Bornet and Flahoult and some *Centroceras clavulatum* (Agardh) Montagne	20	21
Lyngbya majuscula Gomont with some *Bryopsis pennata* var. *secunda* (Harvey) Collins and Hervey	45	22
CORONA DEL MAR, CALIF.		
Pelvetia fastigiata Gardner	100	16
Hesperophycus harveyanus Gardner	100	16
Corallina officinalis var. *chilenus* (Harvey) Kützing	0	—

TABLE 4.—RESULTS OF CONCENTRATION OF ALGAL EXTRACTS

Species	Type of extract	Deaths (%)	Average death time (hours)
Boodlea composita (Harvey) Brand, and *Caulerpa serrulata* (Forskål) Agardh, emend. Börgesen	Routine Crude	100	22
	Concentrated	100	0.6
Pelvetia fastigiata Gardner	Routine Crude	100	16
	Concentrated	100	0.9

Summary.—Water extracts of a number of tropical and temperate marine algae have been found to be toxic to mice. Some concentration of the toxin(s) has been achieved and a number of the simple physical and chemical properties determined.

Acknowledgments.—We are much indebted to Dr. Yale Dawson, Allan Hancock Foundation, University of Southern California, for the identification of the algae, and to Dr. John Field, Department of Physiology, School of Medicine, University of California at Los Angeles, for his helpful suggestions.

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BIOCHEMISTRY.—*Bactericidal activity of ozonized olefins.* J. V. KARABINOS and H. J. FERLIN, Blockson Chemical Co., Joliet, Ill.

(Received January 10, 1955)

The germicidal properties of ozonized fats have been well established from studies on olive (*1*, *2*), codliver (*3*), and cottonseed oils (*4*). The nature of the antibacterial factor responsible for this activity is, however, unknown. In a previous article (*5*) it was noted that the bactericidal activity of "ozonides" deteriorated with time and that not all ozonized substances gave the same initial activity. In fact, a polyoxyethylene

condensate of tall oil rosin acids gave practically no bactericidal activity upon ozonization whereas the presence of fatty acids such as oleic or linoleic in the hydrophobic radical resulted in a product of considerable activity after ozonization. It, therefore, seemed desirable to ozonize a variety of olefinic compounds quantitatively and ascertain whether bactericidal activity varied with olefinic structure.

EXPERIMENTAL DETAILS

The olefins used in this study (Table 1) were the purest grades obtainable from Matheson, Coleman and Bell. The ozone was generated with the previously described (*6*) apparatus. Approximately 5 grams of olefin was accurately weighed in a tared flask and subjected to ozonization. At various intervals the flask and its contents were weighed and the increase in weight was noted. When the weight became constant, the ozonization was assumed to be complete and the product was immediately tested for bactericidal activity by the FDA method (*7*) as described in a previous article (*8*) using *Staphylococcus aureus* (*Micrococcus pyogenes* var. *aureus* ATCC No. 6538, FDA strain 209, 1938). The results are shown in Table 1 in terms of dilutions giving positive or negative growth after ten minutes. A comparative rating indicating the degree of bactericidal activity is also included.

It should be mentioned that since the bactericidal activity of the "ozonides" may deteriorate with time, too much emphasis should not be put on the numerical values recorded in Table 1. They should rather be considered from a relative standpoint.

QUANTITATIVE OZONIZATION OF SEVERAL OLEFINS

Undecylenic acid (8.4266 g) was placed in a tared flask (A) followed by a tared trap (B) cooled in a dry ice bath. Ozone gas (5 percent ozone and 95 percent oxygen) was bubbled slowly through the olefinic acid and at regular intervals the weights of A and B were recorded. After 48 hours, no further increase in weight was observed; however, the material in A continued to distill slowly into trap B. At the end of 70 hours, the volatile material in B, smelling strongly of formaldehyde, weighed 0.73 g (1.37 g of formaldehyde would be considered theoretical) while flask A contained 10.35 g of product. Together the weights of ozonized undecylenic acid weighed 11.08 g whereas a product containing 4 oxygen atoms per double bond would have weighed 11.35 g. This represents 97.5 per cent of theory or 3.9 oxygen atoms per double bond. The only plausible explanation seemed to be that undecylenic acid (I) was being ozonized to formaldehyde (II) and a monoperoxyacid (III).

$$\underset{\text{I}}{CH_2{=}CH{-}(CH_2)_8{-}COOH} + O_3 \longrightarrow$$

$$\underset{\text{II}}{CH_2O} + \underset{\text{III}}{H{-}OOC{-}(CH_2)_8{-}COOH} \xrightarrow{\Delta}$$

$$\underset{\text{IV}}{HOOC{-}(CH_2)_8{-}COOH}$$

To substantiate this hypothesis, the material in trap B was treated with 2,4-dinitrophenylhydrazine and the corresponding phenylhydrazone of m.p. 160° was isolated in a 30 percent yield. The m.p. of formaldehyde 2,4-dinitrophenylhydrazone is listed as 166° (*9*). Control experiments with our reagent indicated that yields of this order could be expected with authentic formaldehyde.

Since monoperoxy acids upon heating at 80–100° C (*10*) liberate oxygen containing gases, resulting in the formation of the corresponding acids, some of the material (1.222 g) in flask A representing 1.18 g as monoperoxy acid was heated in a boiling water bath in a tared test tube. The evolution of gaseous products was noted and when this was no longer observed the weight of the product amounted to 1.093 g. This weight loss corresponded exactly to that required for the loss of one oxygen atom from the monoperoxy acid (III). The heated residue meanwhile had changed from a very viscous oil to a solid which upon recrystallization from ethyl acetate gave m.p. 132° and a neutral equivalent of 99. Since sebacic acid (IV) gives a m.p. of 133° (*11*) and has a neutral equivalent of 101 a mixed melting point with that sub-

stance was determined and no depression was observed. It was also noted that the heat-treated acidic residue did not give a precipitate with 2,4-dinitrophenylhydrazine indicating the absence of any long chain aldehydic product. These data, therefore, strongly indicate that ozonization of undecylenic acid results in the formation of formaldehyde and monoperoxy octane-1,8 dicarboxylic acid (III) as shown above and that this latter substance is indeed responsible for the high order of bactericidal activity.

Caprylene was ozonized in the same manner as undecylenic acid and the increase in weight likewise approached four atoms of oxygen per mole of the olefin. In this case formaldehyde was also isolated as the 2,4-dinitrophenylhydrazone of correct melting point.

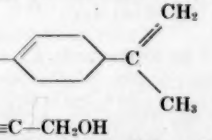
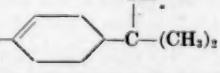
Mesityl oxide on the other hand absorbed ozone gas to a point just short of three atoms of oxygen per mole. In this case acetone was isolated and identified as the 2,4-dinitrophenylhydrazone of m.p. 124°. The residue gave no evidence of peroxy acid formation and this seems to account for the poor bactericidal activity exhibited by this "ozonide."

D-Limonene and *α Terpineol* both absorbed less than three atoms of oxygen per double bond and exhibited poor bactericidal activity.

DISCUSSION OF RESULTS

From the data recorded in Table 1, it becomes apparent that there is great dissimilarity in the germicidal activity exhibited by the ozonization products of various olefins. Upon careful examination of the structures of the parent olefins, however, certain conclusions may be drawn. For example, olefins with a vinyl ($CH_2 =$ CH—) or vinylene (—CH = CH —) group exhibit much better bactericidal properties after ozonization than unsatur-

TABLE 1.—BACTERICIDAL ACTIVITY OF OZONIZED OLEFINS*

Compound	Formula	Dilution giving negative growth after 10 minutes	Dilution giving positive growth after 10 minutes	Comparative rating
Undecylenic acid	$CH_2=CH-(CH_2)_8-COOH$	1-200,000	1-400,000	Superior
Caprylene	$CH_2=CH-(CH_2)_5-CH_3$	1-80,000	1-160,000	Excellent
Oleic acid	$CH_3-(CH_2)_7-CH=CH-(CH_2)_7-COOH$	1-80,000	1-160,000	Excellent
n-Butyl vinyl ether	$CH_2=CH-O-C_4H_9$	1-40,000	1-80,000	Very good
Ethyl undecylenate	$CH_2=CH-(CH_2)_8-COOC_2H_5$	1-40,000	1-80,000	Very good
Ethyl cinnamate	$C_6H_5-CH=CH-COOC_2H_5$	1-20,000	1-40,000	Good
Allyl alcohol	$CH_2=CH-CH_2OH$	1-20,000	1-40,000	Good
Linalool	$(CH_3)_2-C=CH-(CH_2)_2-C(OH)(CH_3)-CH=CH_2$	1-10,000	1-20,000	Fair
Mesityl oxide	$(CH_3)_2-C=CH-CO-CH_3$	1-1,000	1-5,000	Poor
D-Limonene		1-1,000	1-5,000	Poor
Propargyl alcohol	$CH\equiv C-CH_2OH$	1-1,000	1-5,000	Poor
2-Butyne,1,4 diol	$HO-CH_2-C\equiv C-CH_2-OH$	—	1-1,000	Neg.
α-Terpineol		—	1-1,000	Neg.

* The bactericidal activities recorded above were carried out on the above olefins after each had been fully treated with ozone. In most cases, this required about 70 hours.

ated compounds having no hydrogen atom substituted on one of the carbon atoms of the double bond (i.e., >C = CH—). Likewise, acetylene compounds (—C ≡ CH) having none or one hydrogen atom on the triple bond give relatively inactive "ozonides." The length of the fatty chain does not seem to be as pertinent as the type of carbon to carbon double bond.

One might, therefore, classify the vinyl and vinylene double bonds as "desirable" for bactericidal activity upon ozonization and the latter two types as "undesirable".

Several peculiarities may be noted. For example, linalool with two double bonds, one of the vinyl type and the other not, possesses better bactericidal activity than mesityl oxide with only one double bond of the "undesirable" type. It will also be noted that D-limonene with two double bonds of the undesirable type gives an "ozonide" of low activity. These data seem to indicate that one olefin does not necessarily produce the same ozonization product as does another. Heretofore, it was thought that all double bonds were converted by ozone to ozonides (I) or in some cases to hydroperoxides (II) (*12*) particularly where a solvent was employed.

I II

In our experiments, it was noted that those olefins such as oleic acid which did not produce volatile byproducts, took up four atoms of oxygen for each double bond instead of the three expected for a simple ozonide or hydroperoxide. In several instances where volatile products were obtained, such as with undecylenic acid, it was noted that formaldehyde, identified as its 2,4-dinitrophenylhydrazone of m.p. 162–4°, was isolated from the volatile fraction. It would seem, therefore, that three oxygen atoms were consumed by the remainder of the molecule indicating the possible formation of a monoperoxyacid (III). This postulate was further substantiated by converting the monoperoxyacid by heat to sebacic acid with the loss of one oxygen atom. Similar experiments with several other olefins indicated that the ones with double bonds of the "desirable" type absorbed four atoms of oxygen per double bond while those which gave poor bactericidal activity upon ozonization took up only three atoms of oxygen. It may also be mentioned that peracetic acid was synthesized (*13*) in connection with this work and possessed bactericidal activity in dilutions of the order of 1–100,000 using the FDA procedure lending further support to the above hypothesis.

SUMMARY

Ozone gas was passed into a variety of olefinic compounds and bactericidal activity of the resultant products indicated that there is great variation in activity depending upon the type of olefin used. It would seem that at least one hydrogen atom on each of the carbon atoms of the double bond is essential for bactericidal activity. The results indicate that the bactericidal principle may be a peroxyacid.

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PALEONTOLOGY.—*A new species of mylagaulid from the Chalk Cliffs local fauna, Montana.* MALCOLM C. MCKENNA, University of California. (Communicated by C. Lewis Gazin.)

In the course of field work in 1950 Dwight W. Taylor and the writer collected fossil vertebrate material briefly at exposures in the sediments interbedded in the volcanics along the banks of the Yellowstone River, 23.6 miles north of Gardiner, Mont. Collections from this locality have been designated the Chalk Cliffs local fauna by Wood et al. (1941). The specimens obtained in 1950 were a right scaphoid of a camelid about the size of a llama, a P^3 or P^4 of *Parahippus* cf. *P. brevidens*, merychippine cheek tooth fragments (not retained), several tortoise limb bone fragments, and the incomplete mylagaulid skull herein described. These specimens suggest a probable early Barstovian age for the Chalk Cliffs local fauna. I am indebted to Seth B. Benson for his advice on dental succession and to R. A. Stirton, D. E. Savage, and R. H. Tedford for their criticism of the manuscript. The drawings are by Owen J. Poe.

Mylagaulus douglassi, n. sp.

Type.—U. C. 44694, named in honor of Earl Douglass.

Type locality.—U. C. M. P. Loc. V-5060, exposures next to the highway on the east side of the Yellowstone River, 23.6 miles north of Gardiner, Mont.

Distribution.—Type locality only.

Age.—Early Barstovian or possibly latest Hemingfordian.

Diagnosis.—Very large mylagaulid (Fig. 1.) with posteriorly closely approximated temporal crests; hornless, essentially flat, unelevated nasals; skull flat from nasals to occipitals, not anteroposteriorly compressed; teeth small in comparison to skull size; P^2 absent; M^2 and M^3 bearing five fossettes each; P^4 oval, with divided anterofossette at early stage of wear, parafossette round and tiny, metafossette double, slight angulation in mesostylar region; cement absent from sides of teeth; capsule of P^4 forming shelf at rear of infraorbital foramen; sphenopalatine foramen a large, anteroventrally trending slit, well separated from orbital fissure; nasolacrimal and accompanying foramen large, at rear of infraorbital foramen; nutrient foramina anterior to sphenopalatine multiple, not single; optic foramen small; anterior ethmoid foramen small.

Discussion.—*Mylagaulus douglassi* is a very large mylagaulid, equaled in size by the Pliocene *Epigaulus hatcheri* alone among members of the family. The skull herein described is approximately thirty percent larger than the skull of a described but unnamed Pliocene mylagaulid from Big Spring Canyon, S. Dak. (J. T. Gregory, 1942), and a minimum of fifty percent larger than all other described skulls of *Mesogaulus* or *Mylagaulus*. Pliocene mylagaulids became larger than those of the Miocene as a rule, but, what is more important, fourth premolar size increased at an appreciably greater rate than skull size. For this reason it would be premature to state that various large premolars from Hemphillian localities represent animals with larger skulls than that of *Mylagaulus douglassi*, even though the teeth of *M. douglassi* are smaller. Another prominent feature of *M. douglassi* is that dorsally the skull does not show the extreme anteroposterior compression shown by late Barstovian and later forms. In general aspect, the skull is reminiscent of the skulls of *Promylagaulus*, *Mylagaulodon*, and *Aplodontia*, rather than of the late Barstovian and Pliocene mylagaulids. Horns were apparently absent, though a slight elevation is possibly indicated by the broken anterior edges of the nasals.

In dental pattern comparisons must be made with great care in view of the variation shown by various stages of wear, but it can be stated cautiously that *M. douglassi* compares most favorably with *Mesogaulus vetus*, *Mylagaulus laevis*, and the Mascall mylagaulid, especially with the Mascall form and the type and numerous referred specimens of *M. laevis*. The parafossette of P^4 differs from that in the type of *M. laevis* and from that of the apparently more advanced referred specimens of *M. laevis* from Skull Spring and Beatty Buttes, Oregon, in that this fossette is small and round, as in the referred specimens of *M. laevis* from the lower Snake Creek and in *Mesogaulus vetus*. Specimens numbered 14310 in the Peabody Museum, Yale University, from the Mascall formation at

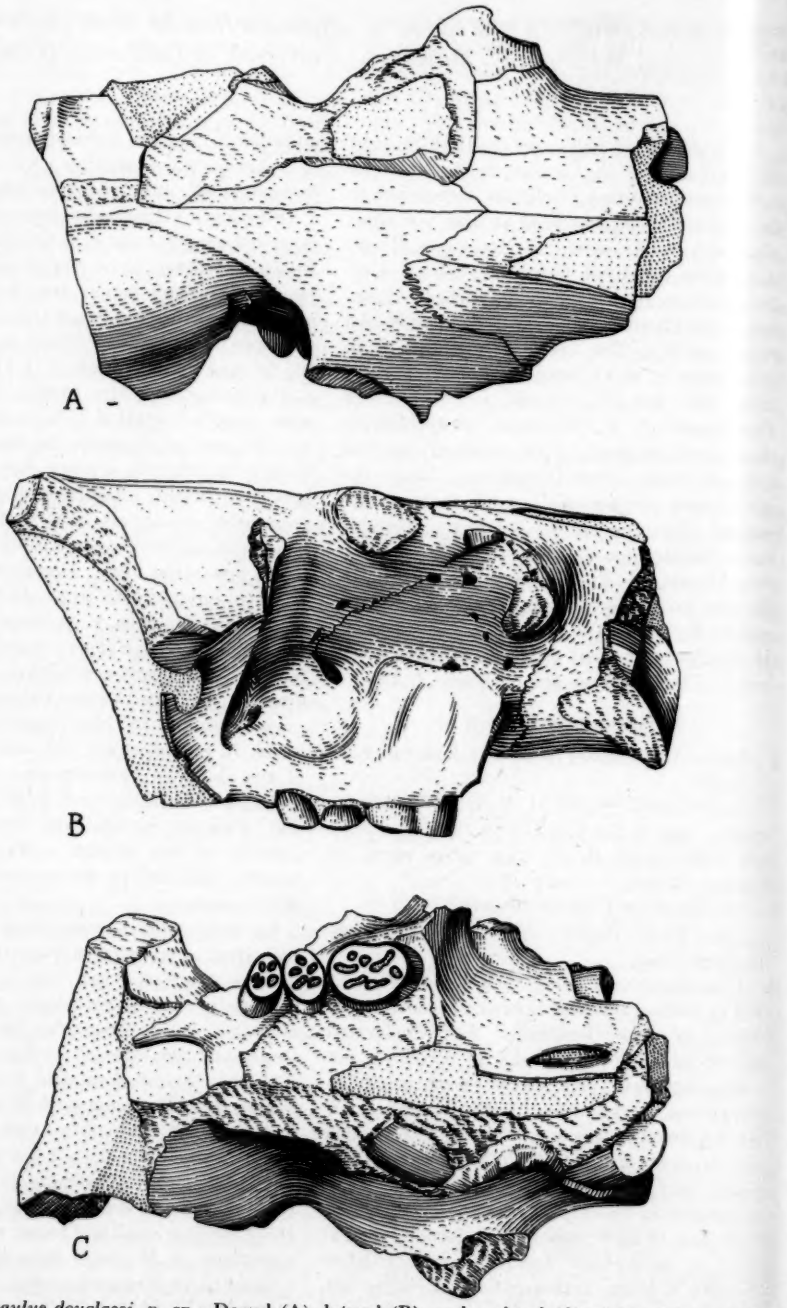

FIG. 1.—*Mylagaulus douglassi*, n. sp.: Dorsal (A), lateral (B), and occlusal (C) views of fragmentary skull, U. C. 44694. × 1½

Paulina Creek in the Crooked River region of Oregon show a pattern almost identical with that of the P^4 of *M. douglassi* and the lower Snake Creek referred specimens of *M. laevis*, but they average twenty percent smaller than *M. douglassi* teeth. Perhaps it would be useful to speak of the *Mylagaulus laevis* group, in analogy to the *Aelurodon saevus* group. The members of the *M. laevis* group would be *M. laevis*, the referred specimens of this species from various localities, the Mascall form, and *Mylagaulus douglassi*. The parafossette of these forms differs radically from that of *Mesogaulus pristinus* or of any of the Pliocene mylagaulids, in which the parafossette is elongate or multiple.

The placement of *M. douglassi* in Mylagaulus instead of in *Mesogaulus* is somewhat arbitrary in view of the fact that it is not known whether there was a parafossettid. But as *M. douglassi* belongs to the *Mylagaulus laevis* group on the basis of other characters, it seems probable that there was a small parafossettid as in the other members of the group. Direct comparison of *M. douglassi* with *Mesogaulus ballensis* from the nearby Deep River beds is impossible at present, but a considerable size discrepancy exists between the two forms.

Dorr (1952) has recently proposed that the adult mylagaulid cheek dentition becomes P^4_4, M^1_1,M^2_2. Matthew (1924) stated that the adult cheek dentition becomes P^4_4,M^2_2,M^3_3. Matthew's formula is followed in the present paper for the following reasons, though the question cannot yet be regarded as completely settled. First of all, a simple, permanent P^3 is present in *Promylagaulus riggsi*, *Mylagaulodon* cf. *M. angulatus*, *Mesogaulus paniensis*, *Mesogaulus vetus*, possibly *Mesogaulus praecursor*, and *Aplodontia*. This tooth is pushed out by the emerging P^4 in the advanced mylagaulids. That it is a permanent P^3 is attested by analogy with *Aplodontia*, in which a deciduous, peg-like P^3 may be observed in young animals. Deciduous and permanent P^3 thus accounted for, the two teeth replaced next must be dP^4 and M^1. In the skull of *Mylagaulus* from Big Spring Canyon it is possible that a second molar was pushed out by P^4 in old age, though it still could be that the rear molars have been lost. I know of no specimens, however, that show marked reduction in the last molar of the series, a condition which might be expected to precede loss of such a tooth in most instances.

Dorr states (1952, pp. 322) with regard to the lower dentition that "it is difficult to suppose that as M_1 (instead of dP_4) it would remain brachyodont in the midst of a strongly hypsodont dentition". However, it would seem reasonable that since dP^4_4 and M^1_1 erupt at about the same time, that they could look more similar than Dorr suggests, i.e., that both could be brachydont, particularly in view of the depth of jaw available for teeth in such a young animal. An example of what is meant here is provided by the artiodactyl *Phacochoerus*, in which M^1_1 are pushed out of the series by the remaining molars and P^4_4.

Secondly, the two rooted condition of M_1 and narrow, single rooted condition of M^1 easily could be a simple adaptation to the enlarging P^4_4. This would be in response to crowding by P^4_4 and would mimic the process whereby deciduous teeth are replaced, a process whose genetic control is undoubtedly very deep-seated and influenced by modifiers such as genes for resorption.

Thirdly, at least in M^1, a specimen of *Mylagaulus* from the type Mascall formation, U. C. 39292, shows that the dental pattern of this tooth is closely similar to that of M^2 and M^3. In addition to this, the dP^4 and M^1 of *Mesogaulus vetus* differ markedly in outline, as do the same teeth in an undescribed specimen of a mylagaulid from the Burge fauna in the University of California collections.

Fourthly, Dorr's objection to the eruption of M_1 as part of the "premolar series" seems unfounded. This is the normal situation in rodents as well as in many other groups.

These considerations strongly suggest that Matthew was correct in giving the adult mylagaulid cheek tooth formula as P^4_4,M^2_2,M^3_3 for advanced forms. Arguments based on induction and analogy cannot provide certainty, but probability seems to lie on the side of Matthew's formula rather than Dorr's. In addition, arguments for the Matthew formula are somewhat simpler than those in favor of Dorr's formula, a situation which is advantageous on empirical grounds.

Wood et al. (1941) list the following members of the Chalk Cliffs local fauna:

Merychippus cf. *M. isonesus* [*M. seversus*]
Mylagaulus sp.
"*?Cosoryx*" sp. [*?Merycodus* sp.]
Proboscidea

A camelid, tortoise, and *Parahippus* cf. *P.*

brevidens (Fig. 2.) may now be added to the faunal list. The closest relationships of the Chalk Cliffs local fauna would seem to lie with the Mascall fauna, indicating an early Barstovian age, but latest Hemingfordian age is not impossible. The stage of evolution of *Mylagaulus douglassi* is as might be expected in either a late Hemingfordian or early Barstovian mylagaulid, with a small weight of probability in favor of the latter age. Thus far, *Parahippus brevidens* has been known only from the early Barstovian Mascall fauna.

FIG. 2.—*Parahippus* cf. *P. brevidens*: Occlusal view of P^3 or P^4. × 1.

Measurements (in millimeters).— As follows:

Length, P^4–M^3, inclusive	17.4
Length, P^4	8.8
Length, diastema from incisor to P^1	24.4
Length, at midline, occiput to nasofrontal contact	43.6
Width, P^4	6.8
Height, maxilla at P^4 to nasofrontal contact	31.1

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BOTANY.—*Studies in the Begoniaceae, IV.*[1] LYMAN B. SMITH, U. S. National Museum, and BERNICE G. SCHUBERT, U. S. Department of Agriculture.

This number of our series is an addendum to floristic treatments of the family for Peru,[2] Argentina,[3] and Colombia,[4] and a preface to further floristic papers.

VENEZUELA

Begonia steyermarkii Smith & Schubert, sp. nov. FIGS. 1, *a–h*

Herba annua fugitiva; foliis oblique rhombicis, apicem versus serratis; inflorescentiis bifloris; bracteis persistentibus, laceratis; tepalis masculinis 2, integris; filamentis in columnam connatis, antheris elongatis; bracteolis femineis 2, persistentibus, accrescentibus, una bilobata; tepalis femineis 4, basi connatis; placentis simplicibus, stylis 3, bifidis, stigmatibus spiraliter cinctis; alis capsulae inaequalibus.

Herbaceous annual 6–10 cm high; stem simple, hirtellous, ascending; leaves asymmetric, obliquely rhombic, acute at apex and more or less so at base, subpalmately veined, rather coarsely serrate on the upper margins and ciliate on the lower, up to 15 mm long and 8 mm wide, with erect multicellular scattered trichomes above, essentially glabrous below, petioles 1–3 mm long with a few scattered spreading trichomes, stipules persistent, lanceolate, acuminate, ciliate, 4–5 mm long, 1–1.5 mm wide; peduncles axillary 8–10 mm long, sparsely hirtellous; inflorescences 2-flowered, bracts persistent, lanceolate, lacerate, 1.5–2 mm long; staminate pedicels slender 2.5–3 mm long; staminate tepals 2, subelliptic, 5 mm long, 3.5 mm wide; stamens about 15, filaments connate in a column, anthers elongate, the connective slightly

[1] The previous number in this series was this JOURNAL **40**(8): 241–245. 1950.

[2] *Begoniaceae*. In Macbride, Flora of Peru. Field Mus. Nat. Hist. Bot. **13**[4]: no. 1: 181–202. 1941.

[3] *Revisión de las especies Argentinas del género* Begonia. Darwiniana **5**: 78–117, *figs. 1–18*. 1941.

[4] *The Begoniaceae of Colombia*. Caldasia **4**: 3–38, 77–107, 179–209, *pls. 1–18*. 1946.

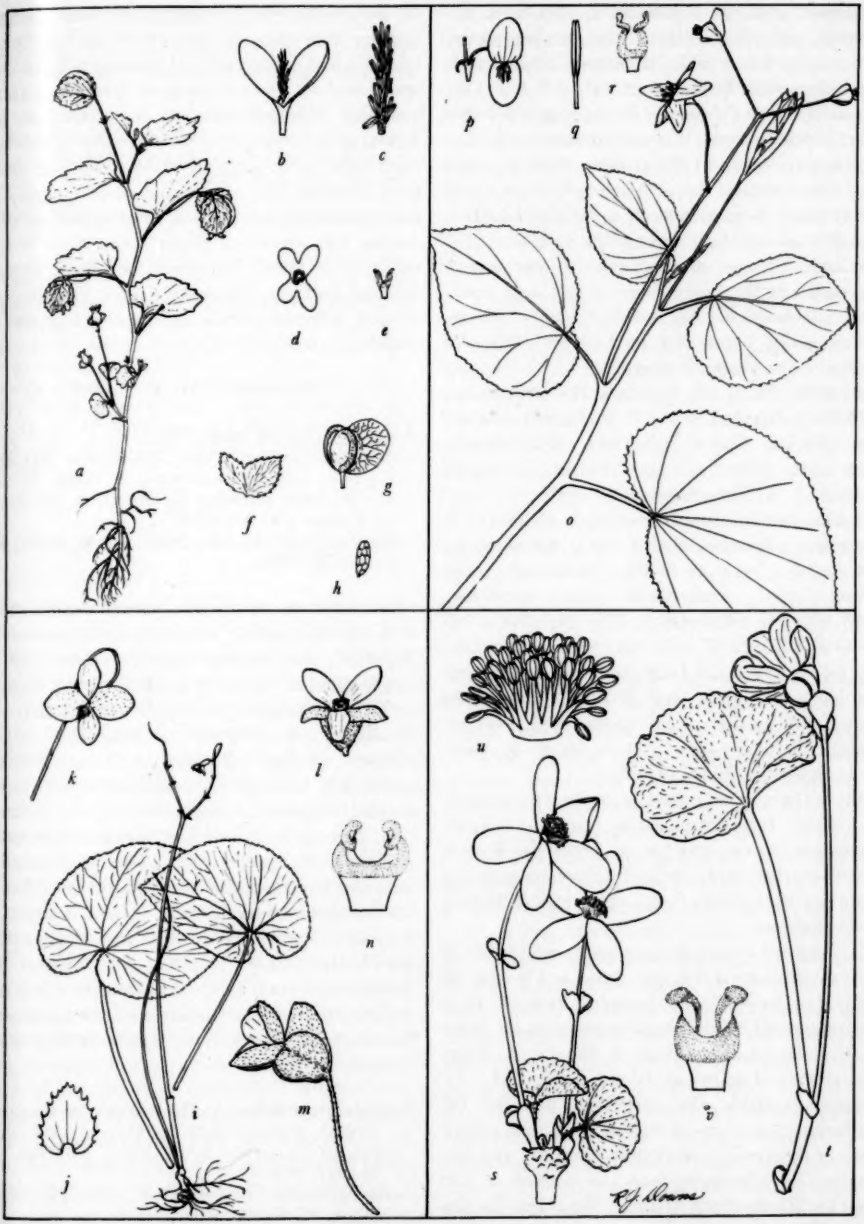

FIG. 1.—*a*, *Begonia steyermarkii*, plant × 1; *b*, staminate flower × 2; *c*, androecium × 5; *d*, pistillate perianth and styles × 2; *e*, style × 5; *f*, larger pistillate bracteole × 1; *g*, capsule (bracteoles removed) × 1; *h*, seed × 10. *i*, *Begonia bifurcata*, plant × ¼; *j*, stipule × 5; *k*, staminate flower × 1; *l*, pistillate flower × 1; *m*, capsule × 1; *n*, style × 5. *o*, *Begonia brevicordata*, inflorescences and upper leaves × 1: *p*, staminate flower × 1; *q*, stamen × 5; *r*, style × 5. *s*, *Begonia sleumeri*, staminate plant × 1; *t*, pistillate plant × 1; *u*, androecium × 5; *v*, style × 5.

produced; pistillate bracteoles 2, persistent, accrescent, serrulate-ciliolate, the smaller ovate, 8 mm long, 5 mm wide, the larger bilobed with the halves slightly asymmetrical, 6–7 mm long and each 4–5 mm wide; pistillate pedicels 6–7 mm long; pistillate tepals 4, fused at base, each lobe ca. 2.5 mm long and 1.5 mm wide; styles 2-parted with the stigmatic tissue in a more or less spiral band; ovary 3-celled, placentae simple, ovuliferous throughout, capsule subelliptic, glabrous, 6 mm high, 2 wings subequal about 6 mm long, 2 mm wide, the third wing larger, 7 mm long, 6 mm wide, all more or less rounded; seeds oblong, obtuse, about 1 mm long, stalked, alveolate, the basal alveolae longer than wide.

Type in the U. S. National Herbarium, no. 2144327, cultivated at the U. S. Plant Introduction Garden, Glenn Dale, Md. (PI 211848), from seeds sent from the Missouri Botanical Garden, J. A. Steyermark (no. 75502).

Additional specimens examined: Bolívar: On dry ledges, Chimantá Massif, along base of southeast-facing sandstone bluffs of Chimantá-tepuí (Torono-tepuí), from south corner northeastward, altitude 1,700 meters, May 21, 1953, *J. A. Steyermark* 75502 (F, US). Around dry talus with dry leaves at base of bluff, between Bluff Camp and low promontory north of Bluff Camp, along west-facing portion of Chimantá-tepuí (Torono-tepuí), altitude 1,600–1,700 m, June 5, 1953, *J. A. Steyermark* 75639 (F, US).

Since the original collection of Dr. Steyermark, no. 75502, has very mature fruit but neither leaves nor flowers, and his no. 75639 has flowers but no mature fruit, we have chosen as type the more complete plants from a cultivated collection as cited above.

The species is easy to propagate, but the life of each small plant is not very long, and it is to be cultivated more for its botanical interest than its ornamental value. We are grateful to Dr. John L. Creech, superintendent of the U. S. Plant Introduction Garden at Glenn Dale, Md., for making available the cultivated material for herbarium specimens as well as additional collections of flowers in preservative for study and dissection. We also appreciate the interest of Dr. Fred G. Meyer of the Missouri Botanical Garden in sending us seeds and specimens of this interesting species.

The affinities of *Begonia steyermarkii* are clearly in the section *Poecilia* A. DC. It may be distinguished from the other South American species of the section by its relatively long stamen-column with elongate anthers, by its bracteoles, one of which is 2-lobed and surrounds 2 capsule-walls, and by its gamotepalous 4-lobed pistillate perianth. This last character is an especially interesting one since it is the character which has been used to distinguish three small segregates from *Begonia*. The appearance of gamotepaly in this connection leads us to believe that at least among the American Begoniaceae it is of less significance than the characters used to distinguish sections, apparently having evolved at several different points in the development of *Begonia*.

COLOMBIA AND ECUADOR

Begonia L. Sp. Pl. 1056. 1753.
Begoniella Oliver, Trans. Linn. Soc. **28**: 513. 1873; emended by Oliver in Hook. Ic. **14**: 38. 1881; emended by Smith & Schubert, Caldasia **4**: 204. 1946.
Semibegoniella C. DC. Bull. Herb. Boiss. II. **8**: 327. 1908.

As noted above (under *Begonia steyermarkii*), it is our feeling that the characters upon which *Begoniella* and *Semibegoniella* were based are no longer tenable. In our treatment of the Begoniaceae of Colombia (p. 205), we stated that the transition from *Begonia* to *Begoniella* "is obviously through *Begonia* § *Casparya* and specifically through *B. killipiana* which rather strikingly resembles *Begoniella whitei*." In addition, *Begonia killipiana* has biseriate stamens as in *Begoniella whitei* and *libera* and *Begonia hexandra* Irmscher. Since this character of biseriate stamens occurs in both genera it lends no support of correlation with the character of gamotepaly. There is even less support for *Semibegoniella* as only the staminate tepals are connate there. Consequently we have transferred the species to the section *Casparya* of *Begonia* as follows:

Begonia grewiifolia (A. DC.) Warb. in Engler & Prantl, Pflanzenfam. **3**: Abt. 6a: 146. 1894.
Casparya grewiifolia A. DC. Ann. Sci. Nat. IV. **11**: 117. 1859.
Semibegoniella jamesoniana C. DC. Bull. Herb. Boiss. II. **8**: 327. 1908.
Semibegoniella sodiroi C. DC. l. c.

Begonia irmscheri Smith & Schubert, nom. nov.
Begoniella angustifolia Oliver in Hook. Ic. **15**: 68, *pl.* 1487. 1885; Smith & Schubert, Caldasia **4**: 208, *pl.* 18. 1946, non *Begonia angustifolia* Blume, 1827–28.

Begonia kalbreyeri (Oliver) Smith & Schubert, comb. nov.
Begoniella kalbreyeri Oliver in Hook. Ic. **14**: 38, *pl. 1352*. 1881; Smith & Schubert, Caldasia **4**: 208, *pl. 18*. 1946.

Begonia kalbreyeri var. **glabra** (Smith & Schubert) Smith & Schubert, comb. nov.
Begoniella kalbreyeri var. *glabra* Smith & Schubert, Journ. Washington Acad. Sci. **40**: 244. 1950.

Begonia lehmannii (Irmscher) Smith & Schubert, comb. nov.
Begoniella lehmannii Irmscher, Bot. Jahrb. **74**: 630. 1949.

Begonia libera (Smith & Schubert) Smith & Schubert, comb. nov.
Begoniella libera Smith & Schubert, Caldasia **4**: 206, *pl.* 18. 1946.

Begonia oliveri Smith & Schubert, nom. nov.
Begoniella whitei Oliver, Trans. Linn. Soc. **28**: 513, *pl. 41*. 1873; Smith & Schubert, Caldasia **4**: 205, *pl. 18*. 1946, non *Begonia whytei* Stapf. 1905.

PERU

Begonia bifurcata Smith & Schubert, sp. nov. FIGS. 1, *i–n*

Perennis, tuberosa; caule quam petiolis pedunculisque multo breviore; foliis paucis, late ellipticis, valde asymmetricis, stipulis deciduis, pedunculis elongatis; inflorescentia pauciflora, bifurcata; tepalis exterioribus glanduloso-hispidis; tepalis masculinis 4; filamentis in columnam angustam connatis; tepalis femineis 5; placentis bilamellatis; stylis 3, bifidis, ramis linearibus, stigmatibus spiraliter cinctis; capsula hispida alis valde inaequalibus.

Perennial from a tuberous base, 28 cm high, sparsely hispid; stem erect, slender, 5 cm long; leaves oblique or transverse, broadly elliptic, acute, sometimes with a small secondary lobe, deeply and narrowly cordate at base, to 13 cm long and 9 cm wide, palmately 8-nerved, denticulate, thin, petioles slender, to 14 cm long, pilose, stipules deciduous, broadly ovate, acute, 5 mm long, dentate, membranaceous; peduncles to 17 cm long; inflorescence 2-branched, few-flowered; bracts persistent ovate, subentire, setose-ciliate; fruiting pedicels 25 mm long; tepals pale rose, the outer bearing stiff hairs with dark swollen bases; staminate tepals 4, elliptic, obtuse, subequal, 6 mm long, entire; stamens borne on a slender column 1.5 mm long, anthers elliptic-oblong, 1 mm long, about equaling the filaments, connective not produced; pistillate tepals 5; ovary 3-celled, placentae bilamellate, styles bifid, stigmatic tissue linear, spiral; capsule more or less decurved, subglobose, wings very unequal, the largest triangular-ovate, ascending, 5 mm wide, the others narrowly marginiform.

Type in the U. S. National Herbarium, no. 2057660, collected in forest, above Canchaque, Province of Huancabama, Department of Piura, Peru, altitude 1,500–1,600 meters, March 22, 1948, by Ramón Ferreyra (no. 3103).

This species would fall next to *B. monadelpha* (Kl.) R. & P. in our key to Peruvian *Begonia* because of its stamen-column but is otherwise completely unlike it. Except for the stamen-column it would more appropriately go next to *B. veitchii* Hook. f. from which it differs in its long petioles, transverse leaf-blades, and narrow anthers. We feel that as might be expected from its native locality it is more nearly related to the Ecuadorian *B. parcifolia* C. DC. than to any Peruvian species, but unlike that it has the outer tepals and capsule glandular-hispid.

The habit has been drawn with breaks between the parts to indicate reconstruction from fragmentary material.

Begonia brevicordata Smith & Schubert, sp. nov. FIGS. 1, *o–r*

Glabra; foliis obliquis, late ellipticis vel ovatis, basi abrupte breviterque cordatis, stipulis deciduis; inflorescentia laxe pauciflora; bracteis deciduis; tepalis albis, masculinis 2, ovatis, obtusis; staminibus liberis; tepalis femineis 5; placentis bilamellatis; stylis 3, bifidis, basi connatis; alis capsulae inaequalibus.

Plant 40 cm high, glabrous; stems slender; leaves oblique, broadly elliptic or ovate, abruptly acute, abruptly and shallowly cordate at base, 4–5 cm long, denticulate, finely alveolate when dry, petioles 15–50 mm long, stipules deciduous, elliptic, subulate-acuminate, 11 mm long, entire; peduncles 3–8 cm long, slender; inflorescence laxly few-flowered; bracts deciduous, the basal ones like the stipules, the others much smaller; pedicels 10–12 mm long; tepals thin, white, the staminate 2, ovate, obtuse, 6–10 mm long, entire, minutely red-glandular on the margin; stamens free, numerous, anthers linear, longer than the filaments, connective not produced; pistillate flowers bracteolate; pistillate tepals 5, the outer red-glandular at apex; ovary 3-celled, placentae bilamellate, styles bifid, connate at base, stigmatic tissue linear, spiral; capsule erect, obovoid, wings unequal, ovate, obtuse.

Type in the U. S. National Museum, no.

1952111, collected on the edge of woods, Santa Isabel, Valley of Kosñipata, Department of Cuzco, Peru, altitude 1,320 meters, December 1947, by C. Vargas C. (no. 6767). Duplicate in the Gray Herbarium.

Additional specimen examined: Cuzco: Santa Isabel, Valley of Kosñipata, alt. 1,200 m, July 23–31, 1948, *R. Scolnik* 927 (US).

Probably the nearest relative of *Begonia brevicordata* is *B. lophoptera* Rolfe, but the latter species unlike ours is pilose and has lobed leaves and thick fleshy papillose-hirsute tepals.

Begonia erythrocarpa A. DC. in Ann. Sci. Nat. IV. **11**: 121. 1859.
Begonia pennellii Smith & Schubert in Macbride, Fl. Peru, Field Mus. Publ. Bot. **13**[4]: 196. 1941.

BOLIVIA

Begonia williamsii Rusby & Nash, Torreya **6**: 47. 1906.
Begonia acrensis Irmscher, Bot. Jahrb. **74**: 605. 1949.

BRAZIL

Begonia curtii Smith & Schubert, nom. nov.
Begonia velata Brade, Arq. Jard. Bot. Rio de Janeiro **10**: 133, *pl. 2*. 1950, non Smith & Schubert, Field Mus. Publ. Bot. **13**[4]: 201. 1941.

We take particular pleasure in this opportunity to commemorate the outstanding work of Dr. Alexandre Curt Brade in Brazilian Begonia.

Begonia egregia N. E. Br. Gard. Chron. III, **1**: 346. 1887.
Begonia quadrilocularis Brade, Rodriguesia **9**: 21, *pl. 6*. 1945.

ARGENTINA

Begonia sleumeri Smith & Schubert, sp. nov. FIGS. 1, *s–v*

Perennis, tuberosa, pilis articulatis vestita; foliis longipetiolatis, suborbicularibus; inflorescentia uniflora; tepalis masculinis 5–6; staminibus in columnam convexam insertis, antheris ellipticis; tepalis femineis 7; stylis bifidis.

Perennial from a small tuberous base, 6–8 cm high, very sparsely pubescent with pale multicellular trichomes; stem erect, not more than 1 cm long; a single leaf with each scape, blade suborbicular and without a distinct apex, cordate, 12–30 mm in diameter, crenate-dentate, petioles to 45 mm long, red, stipules persistent, suborbicular, 3–5 mm long, erose, ciliate, membranaceous, red; peduncle erect, 2–6 cm long, one-flowered; bracts resembling the stipules, pedicels 5–15 mm long; flowers ebracteolate, white; staminate tepals 5–6, elliptic, obtuse, equal, 10 mm long, entire, glabrous; stamens numerous on a convex column, filaments 2 mm long, anthers elliptic, 0.7 mm long, connective not produced; pistillate tepals 7, like the staminate; ovary 3-celled, placentae bifid (?), styles bifid; capsule subglobose, wings unequal, the largest triangular, acute.

Type in the U. S. National Herbarium, no. 2103588, collected on cumbre at Abra de Tiraxi, Department of Tumbaya, Province of Jujuy, Argentina, altitude 3,200 meters, December 31, 1952, by H. Sleumer (no. 3189).

In our treatment of Argentine Begonia, *B. sleumeri* would fall next to *B. tafiensis*. However, it is readily distinguishable from that species by its more numerous tepals, elliptic rather than obovate anthers, and much smaller capsule-wings. It has not been possible to verify the form of the placentae without ruining the single immature capsule available but presumably they are bilamellate.

MYCOLOGY.—*A small* Conidiobolus *with globose and with elongated secondary conidia.* CHARLES DRECHSLER, United States Department of Agriculture, Plant Industry Station, Beltsville, Md.

Most species of *Conidiobolus* that appear adventitiously in agar plate cultures prepared for the isolation of parasitic oomycetes from decaying roots, or that develop in agar plates canopied with small quantities of slowly decomposing plant detritus, would seem moderately coarse in comparison with microscopic fungi generally. In the main, however, they do not share the large dimensions of the very robust *C. utriculosus* Brefeld (1884) on which the genus was founded and by which almost exclusively, it was known for more than half a century. Among my isolations of readily culturable entomophthoraceous fungi two species of *Conidiobolus* are more particularly characterized

by relatively small dimensions of their hyphal segments and reproductive parts. One of these species was recently described elsewhere under the binomial *C. nanodes* Drechsler (1955). The other is described herein, likewise under an epithet meaning "dwarfish."

Conidiobolus pumilus, sp. nov. Mycelium incoloratum sed interdum materiam ambientem vel permeatum tarde obscurans; hyphis sterilibus mediocriter ramosis, plerumque 2–7μ crassis, mox septatis, hic illic inanitis, cellula eorum extrema saepe 75–400μ longa, aliis cellulis eorum plerumque 20–75μ longis; primiformibus fertilibus hyphis singulatum ex cellulis hypharum surgentibus, in parte submersa vulgo 2.2–3μ crassis, in aerem 8–30μ ad lucem protendentibus, in parte protendenti saepius 3.5–7μ crassis, ibi erectis vel acclivibus, apice unum conidium formae globosae ferentibus; conidiis formae globosae violenter prosilientibus, incoloratis, basi papilla 1.2–3.2μ alta et 3–6μ lata praeditis, plerumque ex toto 9–18μ longis et 7.3–14μ latis; conidiis formae elongato-ellipsoideae incoloratis, interdum 8.8–12μ longis et 5–7.5μ latis, in apice hyphae fertilis gracilis oriundis; gracilibus fertilibus hyphis ex conidiis abjunctis singulatim surgentibus, incoloratis, rectis vel aliquid curvis, interdum 30–40μ altis, basi circa 2μ crassis, sursum leniter attenuatis, apice circa 0.8μ crassis.

Habitat in materiis plantarum putrescentibus prope Sanford, Florida.

Mycelium colorless though in many instances causing the substratum or ambient to darken slowly; assimilative hyphae moderately branched, 2 to 7μ wide, soon divided by cross-walls, when actively growing commonly terminating in a segment 75 to 400μ long, the other segments mostly 20 to 75μ long and often disjointed from one another or separated by emptied portions of filament; primary conidiophores colorless, unbranched, arising singly from submerged or prostrate hyphal segments, in their proximal submerged portions often 2.2 to 3μ wide, extending 8 to 30μ into the air toward the main source of light, the aerial portion 3.5 to 7μ wide, erect or inclined, bearing a single globose conidium; globose conidia springing off violently, colorless, mostly 7.3 to 14μ wide and 9 to 18μ in total length inclusive of a basal papilla 1.2 to 3.2μ high and 3 to 6μ wide; elongate ellipsoidal conidia colorless, sometimes 8.8 to 12μ long and 5 to 7.5μ wide, always borne singly on slender conidiophores; slender conidiophores arising singly from individual detached conidia, straight or curved, sometimes 30 to 40μ tall, 2μ wide at the base, tapering gradually upward, about 0.8μ wide at the tip.

Isolated from decaying plant materials collected near Sanford, Fla., on December 31, 1953.

The hyphal segments in *Conidiobolus pumilus*, as in most congeneric forms, vary greatly with respect to size and shape. In the mycelium growing unimpeded on an ample expanse of maize-meal agar substratum the terminal segments of the radially arranged main hyphae at the advancing margin often measure 200 to 400μ in length and 5 to 6μ in width (Fig. 1). Increase in size of a mycelium is accomplished mainly by continued apical elongation of each terminal segment, which thereby is enabled from time to time to cut off a shorter segment proximally; the segments thus delimited one after another each occupying at first a penultimate position in the filament. Noticeable changes in the usual sequence of growth and cell division may result from slight modifications in external conditions. Thus when an actively expanding mycelium in an agar slab excised from a Petri plate culture is placed on a slide, covered with a cover glass, and then exposed to the bright illumination necessary for microscopical examination at high magnification, the terminal segments in many instances soon become abnormally shortened through hastening of cell division at the proximal end (Fig. 2). Once a hyphal segment has been delimited in penultimate position it usually undergoes no subsequent division, though its shape may become modified from evacuation of some portion at either end, and from extension of short branches or protuberances (Figs. 3–8).

The darkening of substratum often observable in cultures of *Conidiobolus pumilus* on maize-meal or lima-bean agar, within 10 or 15 days after planting, is noteworthy mainly because other known members of the genus seem generally incapable of bringing about any similar discoloration. Among congeneric forms only *C. rugosus* Drechsler (1955) invites comparison here, owing to the yellow or orange coloration it shows on maize-meal agar and on other agar media suitable for its sexual reproduction. The bright coloration seen in cultures of *C. rugosus* is due entirely to enormous numbers of yellow zygospores pro-

duced by that species, whereas the darkening in cultures of *C. pumilus* appears to come about from changes effected in the substratum.

In *Conidiobolus pumilus*, as in all other segmented congeneric forms, the conidiophores (figs. 9–15) bearing the primary globose conidia originate singly from individual hyphal segments. A conidiophore given off by a rather deeply submerged hyphal segment must grow upward through the overlying material a considerable distance before it reaches the surface (Fig. 9, s; Figs. 11–14: s). Owing to the delay incurred thereby the empty membrane of the hyphal segment, together with the evacuated proximal portion of the conidiophore, has usually vanished from sight when the conidium is fully delimited (Figs. 12–14), and may, indeed, be quite indiscernible even earlier when movement of protoplasm into the growing conidium is still in progress (Figs. 9, 11). Although a hyphal segment on the surface of the substratum sometimes extends its conidiophore procumbently a short distance (Figs. 10, s; 15, s), its empty envelope usually remains clearly visible at the time the conidium becomes walled off basally (Fig. 15).

The conidium of *Conidiobolus pumilus* springs off forcibly through sudden eversion of its concave basal membrane. Since the papilla resulting from this eversion is generally a little wider than the corresponding modification in *C. nanodes* it merges more gradually with the globose contour of the spore. Consequently the detached globose conidia of *C. pumilus* (Figs. 16–54) in general appear less abruptly papillate than those of *C. nanodes*. When lying on a moist surface they often put forth individually a short stout conidiophore on which is produced a conidium of globose shape like the parent (Figs. 55–62). Less commonly they give rise individually to a slender conidiophore bearing on its tip an elongate-ellipsoidal or obovoid conidium (Figs. 63–65) of the secondary type previously observed in *C. heterosporus* Drechsler (1953), *C. rhysosporus* Drechsler (1954), and *C. rugosus*. The elongate conidia here as in the three species described earlier do not spring off forcibly but become detached (Figs. 66–92) on slight disturbance. Elongate conidia of *C. pumilus* have hitherto been seen only in cultures over 15 days old in which the globose conidia serving as parents had been much reduced in size through prolonged repetitional development. It may be presumed that if their production were to take place in relatively young cultures they would show appreciably greater dimensions than have been indicated for them in the diagnosis.

In its ordinary vegetative germination the globose conidium puts forth a germ hypha (Figs. 93–95) that on unoccupied substratum is capable of growing into an extensive mycelium.

Sexual reproduction, which as a rule occurs promptly and abundantly in cultures of *Conidiobolus nanodes*, has so far not been observed in *C. pumilus*.

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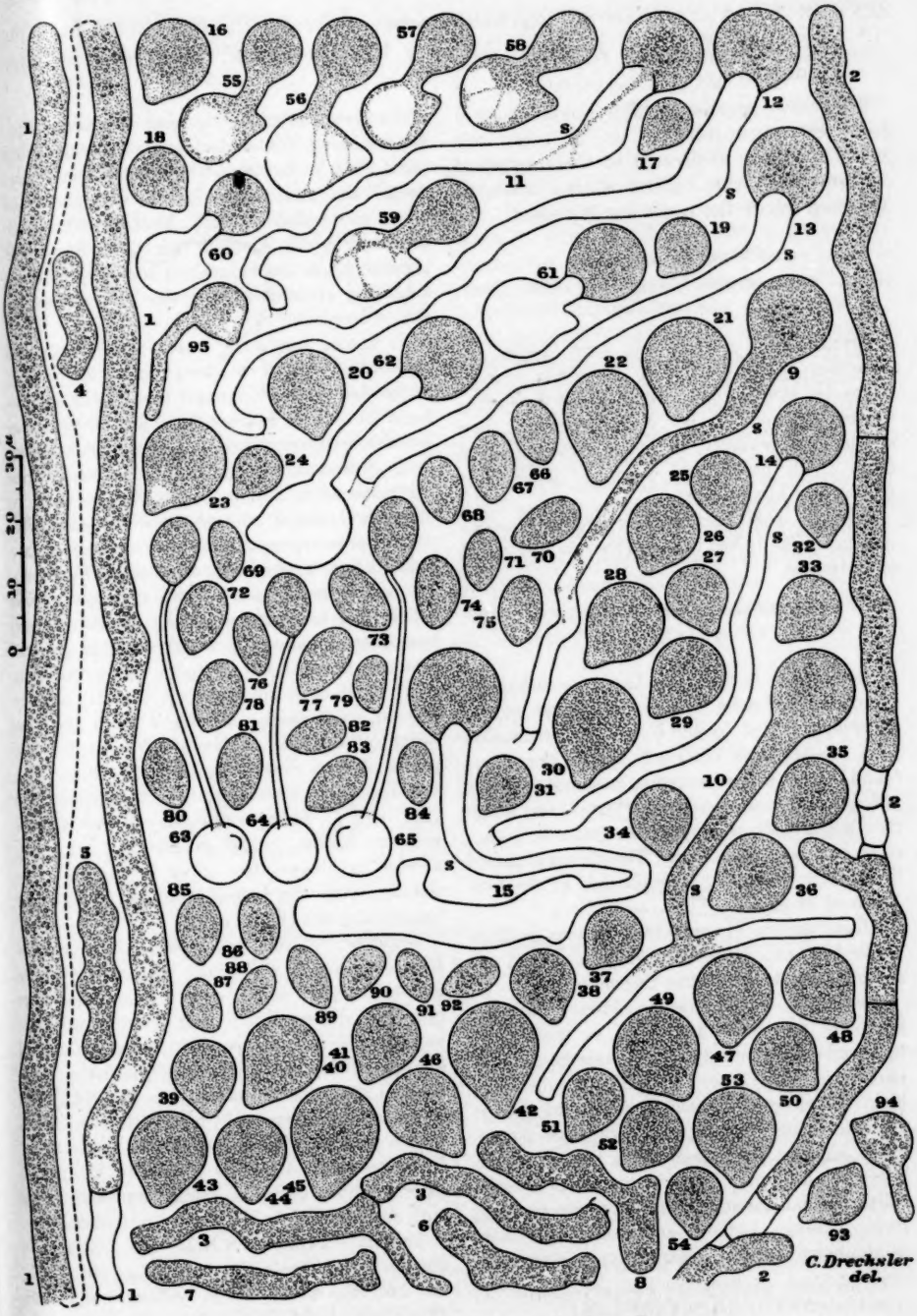
FIGS. 1–95.—*Conidiobolus pumilus* as found in Petri plate cultures of maize-meal agar; drawn at a uniform magnification with the aid of a camera lucida; × 1000: 1, Terminal segment of a main hypha at margin of an actively growing mycelium, shown in two sections whose proper connection is indicated by a broken line; 2, terminal portion of a main hypha at margin of a growing mycelium 45 minutes after material was mounted on a microscope slide and covered with a cover glass; 3, two adjacent hyphal segments in older region of an extensive mycelium; 4–8, individual hyphal segments in central area of an extensive mycelium; 9–11, conidiophores on which globose conidia are being formed (s, surface of substratum); 12–15, conidiophores bearing mature globose conidia (s, surface of substratum); 16–54, detached globose conidia showing variations in size and shape; 55–59, detached globose conidia that are each giving rise to a secondary globose conidium; 60–62, detached globose conidia that have each produced a secondary globose conidium; 63–65, globose conidia that have each produced an elongated secondary conidium on a slender conidiophore; 66–92, detached elongated conidia; 93–95, globose conidia that are each germinating by emission of a vegetative germ hypha.



FIGS. 1–95.—(See opposite page for legend).

ZOOLOGY.—*New species of polychaete worms of the family Polynoidae from the east coast of North America.*[1]

MARIAN H. PETTIBONE, University of New Hampshire.

The new species of Polynoidae herein described were collected in part by the writer; some were present in the unworked collections in the United States National Museum where the types are deposited.

Family POLYNOIDAE

Genus **Austrolaenilla** Bergström, 1916; *char. emend.*

Elytra 15–16 pairs (15 in type species, *A. antarctica* Bergström; 16 in *A. mollis* (Sars)). Notosetae stouter than neurosetae, of the fundamental *Harmothoë* type. Neurosetae with tips slender, not capillary, entire or with secondary tooth, with filamentous hairs on distal ends (bearded or hirsute tips).

Laenilla? mollis Sars, 1872, is herein referred to *Austrolaenilla*. It has been referred to *Harmothoë* and *Antinoë*.

Austrolaenilla lanelleae, n. sp.

Fig. 1, *a–f*

The species is based on three somewhat incomplete specimens which were found in the material collected by the U.S. Fish Commission from off Martha's Vineyard, Mass.; they were found along with numerous specimens of the polynoid, *Harmothoë acanellae* (Verrill) and which they superficially resemble; the latter is known to be associated with corals. The species is named for LaNelle Peterson, museum aide at the U.S. National Museum.

Measurements.—Length 14 to 23 mm, greatest width including setae 5 to 7.5 mm, width excluding setae 3 to 6.75 mm. Segments 40, 41.

Description.—Body nearly linear, tapering gradually anteriorly and more so posteriorly, flattened dorsoventrally. Elytra missing; elytrophores 15 pairs. Prostomium bilobed, wider than long, with deep anteromedian notch and distinct cephalic peaks (Fig. 1, *a*). Four eyes purple, large, anterior pair larger than posterior pair, lateral in position, in region of greatest prostomial width. Median antenna with bulbous ceratophore; style missing. Lateral antennae with short ceratophores inserted ventrally on prostomium; styles short, subulate, tapering to slender tips. Palps missing. Tentacular segment with elongated basal lobes each with a single seta. Tentacular, dorsal and anal cirri missing. Cirrophores of dorsal cirri bulbous basally. Ventral cirri shorter than neuropodia, subulate (Fig. 1, *b*). Segmental papillae begin on segment 6, short, cylindrical, extending upward between the bases of successive neuropodia.

Parapodia biramous, rather long—parapodia and setae about as long as body width; notopodium a short rounded lobe on the anterodorsal face of the neuropodium, with a digitiform acicular lobe; neuropodium bluntly conical (Fig. 1, *b*). Notosetae golden-yellow, numerous, forming a spreading bundle, stout (22.5 to 47.5μ in diameter basally), curved, tapering gradually, with close-set spinous rows, with very short bare pointed tips or tips worn off bluntly (Fig. 1, *c*). Neurosetae golden-yellow, with long stem region (15 to 25μ in diameter basally), with enlarged long distal spinous regions (20 to 30μ in greatest diameter in basal part), spinous region consisting of 17 to 35 or so spinous rows, with tip slightly hooked, with slender secondary tooth (may be broken off or hidden by bushy hairs); the free end of the spinous rows taper to slender hairy tips, the distal row extending about to the setal tip (Fig. 1, *d, f*); the lower neurosetae with shorter spinous regions, with secondary tooth very slender or absent; the upper neurosetae more slender, with the longest spinous regions and longer hairy tips (Fig. 1, *d, e*).

Remarks.—*A. lanelleae* superficially resembles *Harmothoë acanellae* (Verrill), with which it was found, in regard to the general shape and large eyes. It differs by having more numerous notosetae (4–10 in *H. acanellae*), fewer number of segments (50–80 in *H. acanellae*), and the character of the noto- and neurosetae. It differs from *A. antarctica* Bergström by having the neurosetae with a secondary tooth and shorter bushy hairs. It differs from *A. mollis* (Sars) by having 15 pairs of elytra (16 in *A. mollis*) and neurosetae with shorter hairs on the hirsute or bearded tips.

Locality.—Types (U.S.N.M. nos. 26460 and 26461): Off Martha's Vineyard, Mass., 39° 57′ N., 69° 16′ W., 458 fathoms, yellow mud, sand, *Fish Hawk* station 1029, 1881.

[1] This study was aided by a grant from the National Science Foundation (NSF-G526).

Genus **Gattyana** McIntosh, 1897

Gattyana nutti, n. sp.

Fig. 2, *a–f*

The species is based on eight specimens—one collected by D. C. Nutt on the *Blue Dolphin* Expedition of 1949 in the Strait of Belle Isle, Labrador, the others collected by the U.S. Bureau of Fisheries from off Newfoundland to off Cape Cod and reserved for study by A. E. Verrill. It is a dredged form found on bottoms of coral, sand, and pebbles. The species is named for David C. Nutt, commander of the *Blue Dolphin* Expeditions to Labrador.

Measurements.—Length 15 to 16.5 mm, greatest width including setae 4.5 to 4.8 mm, width excluding setae 3.7 to 3.8 mm. Segments 35.

Description.—Body nearly linear, tapering slightly anteriorly and posteriorly, oval in cross section. Body without color. Elytra 15 pairs, oval, imbricated, cover the dorsum, tannish, furnished with long fringe of papillae on lateral and posterior borders as well as on surface, with large, bluntly conical, translucent, amber-colored macrotubercles covering most of posterior half—macrotubercles up to 416μ in length; some intermediate-sized tubercles may have the tips flattened, bifid, or faintly quatrifid; microtubercles more anteriorly on elytra, bluntly conical, mostly with tips bifid, some quatrifid (Fig. 2, *c*).

Prostomium bilobed, wider than long, with deep anteromedian notch, with distinct blunt cephalic peaks (Fig. 2, *a*). Four eyes moderate in size, anterior pair slightly larger than posterior pair, anteroventral in position—not visible dorsally. Median antenna with large bulbous ceratophore, with brown pigment laterally; style nearly as long as the palps, dusky basally, with subterminal enlargement and filamentous tip, with numerous long papillae. Lateral antennae about same length as the prostomial width, short ceratophores inserted ventrally on prostomium; styles dusky, papillate. Palps up to twice the prostomial width, dusky, with short slender tips. Tentacular segment with basal lobes elongated, each with a single seta; two pairs tentacular cirri similar to median antenna, the upper pair about as long as the palps, the ventral pair shorter. Occipital fold posterior to prostomium slightly developed. Dorsal cirri and pair of anal cirri slightly longer than the neurosetae, similar to median antenna, densely papillate. Ventral cirri

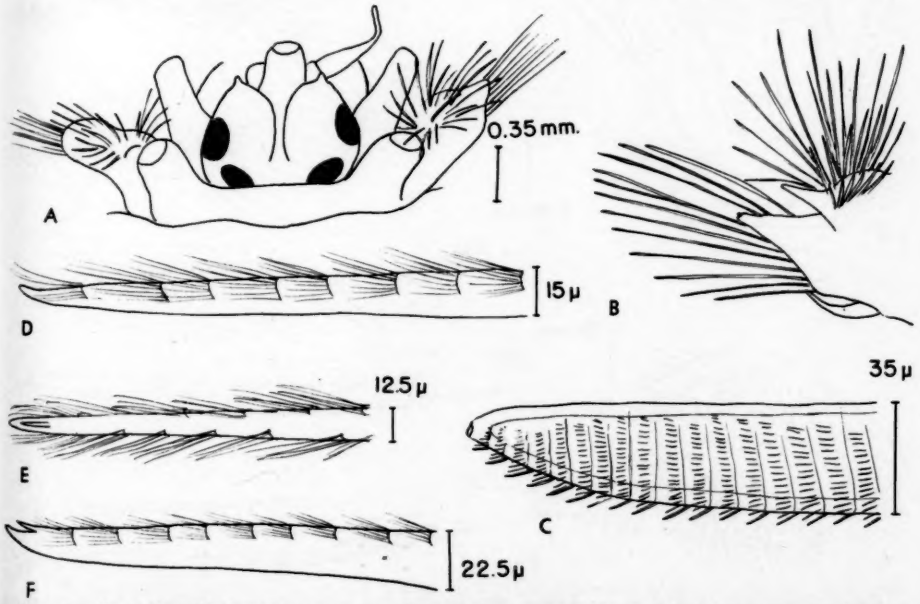


FIG. 1.—*Austrolaenilla lanelleae*, n. sp.: *a*, Dorsal view prostomium and first two segments (elytra, tentacular cirri, and styles of two antennae missing); *b*, fifteenth right parapodium, anterior view; *c*, tip of notoseta; *d*, tip of upper neuroseta; *e*, same, frontal view; *f*, tip of middle neuroseta.

shorter than neuropodia, subulate (Fig. 2, *b*). Segmental papillae begin on segment 6, continuing posteriorly; they become elongated, extending dorsally between the basal parts of the neuropodia.

Parapodia biramous; notopodium a rounded lobe on the anterodorsal face of the neuropodium, with a projecting acicular lobe; neuropodium with a bluntly conical presetal acicular lobe (Fig. 2, *b*). Notosetae light yellow, numerous, forming a bushy bundle, the lower ones extending almost as far distally as the neurosetae; notosetae 7.5 to 15μ in diameter basally, the upper row stouter, more strongly curved, tapering to blunt tips (Fig. 2, *d*), the rest are more slender, tapering gradually to slender tips (Fig. 2, *e*). Neurosetae golden yellow, 12.5 to 22.5μ in diameter basally, with enlarged distal spinous regions (17.5 to 30μ in greatest diameter at basal part of spinous region), with 4 to 17 or so spinous rows and bare hooked tips (spinous region as long as or slightly longer than the bare hooked tips; fig. 2, *f*); the supraacicular neurosetae have longer spinous regions and more slender tips.

Remarks.—*G. nutti* resembles the well-known *Gattyana cirrosa* (Pallas) in most regards; it differs in the character of the elytral macrotubercles.

Locality.—Type (U.S.N.M. no. 23765): Strait of Belle Isle, off Labrador, 51° 41′ N., 56° 20′ W., 25 fms., coral bottom, 1 July 1949, *Blue Dolphin* Expedition; paratypes (U.S.N.M. no. 6344): off Cape Cod, 42° 09′ N., 70° 13′ W., 26 fms., fine brown sand, pebbles, U.S.F.C. 1879, Loc. 330. Also south of Newfoundland, 45° 29′ N., 55° 24′ W., 67 fms., coral bottom, *Albatross* station 2466, 1885; off Nova Scotia, Chebucto Head, entrance of Halifax Harbor, 25 fathoms, fine sand, U.S.F.C. 1878, Loc. 216; Gulf of Maine, N.W. Eastern Point Light, 35 fathoms, fine sand and few pebbles, U.S.F.C. 1878, Loc. 216.

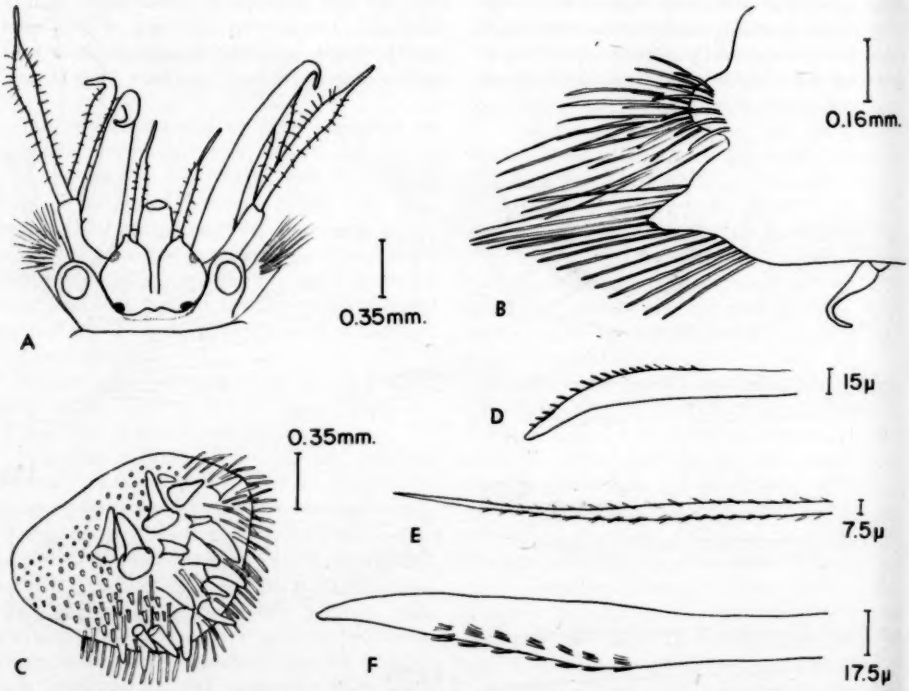


FIG. 2.—*Gattyana nutti*, n. sp.: *a*, Dorsal view prostomium and first two segments (elytra removed, style of median antenna missing); *b*, middle right parapodium, anterior view; *c*, middle right elytron; *d*, upper notoseta; *e*, tip of lower notoseta; *f*, middle neuroseta.

Genus **Harmothoë** Kinberg, 1855, *sensu* Bergström, 1916

Harmothoë dearborni, n. sp.

Fig. 3, *a–i*

The species is represented by a single specimen which was found attached to floating gulfweeds, including *Sargassum*, in Vineyard Sound, Mass. Its color was similar to that of the weed. It is named for John Dearborn, who collected the specimen.

Measurements.—Length 12.5 mm, greatest width including setae 3.75 mm, width excluding setae 2.7 mm. Segments 35.

Description.—Body widest about anterior third, tapering slightly anteriorly and more so posteriorly, oval in cross section. Dorsally body

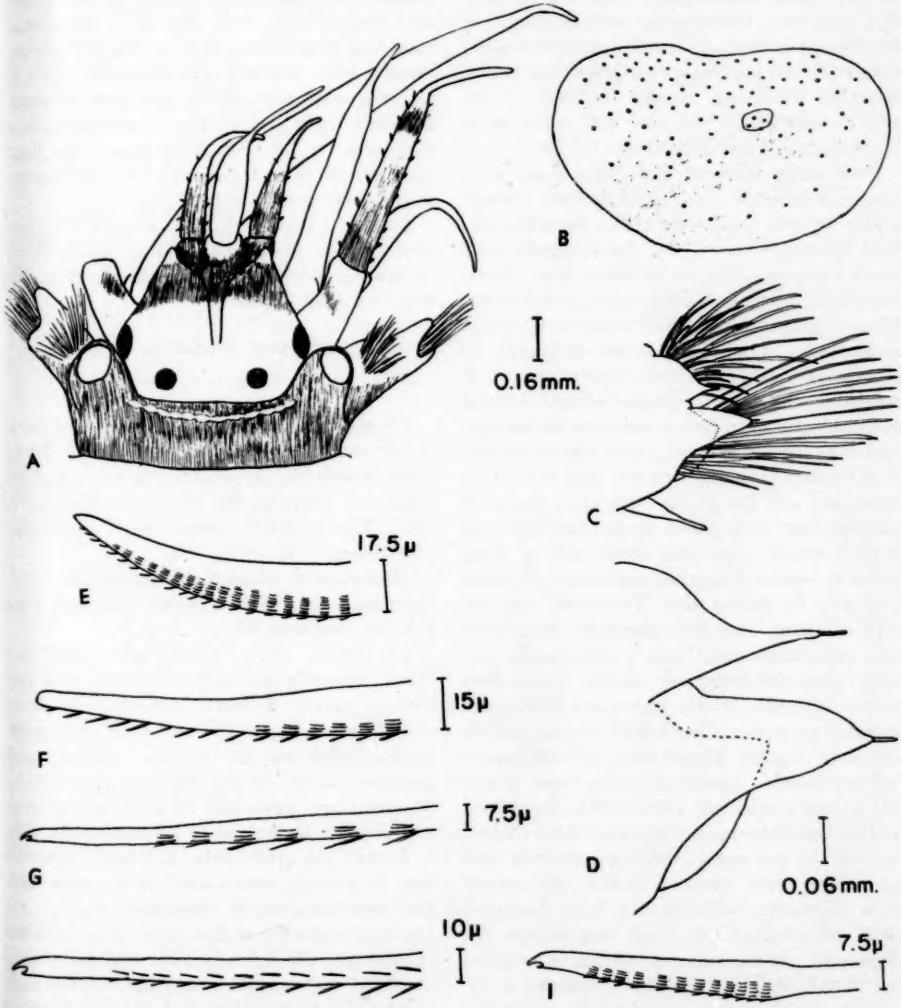


FIG. 3.—*Harmothoë dearborni*, n. sp.: *a*, Dorsal view prostomium and first two segments (elytra removed, left tentacular cirri missing); *b*, middle right elytron; *c*, fifteenth left parapodium, anterior view; *d*, portion of same, without the setae; *e*, tip of upper notoseta; *f*, tip of lower notoseta; *g*, tip of upper neuroseta; *h*, tip of middle neuroseta; *i*, lower neuroseta.

rusty-red (in life) or reddish-brown (in alcohol), with a narrow, somewhat beaded, colorless transverse band on the anterior part of each segment between the dorsal tubercles and elytrophores (Fig. 3, *a*); also a colorless intersegmental band—thus two white bands per segment. Ventral surface dusky, more so anteriorly and especially dark in the region of the mouth. Elytra (Fig. 3, *b*) 15 pairs, oval, overlapping, cover the dorsum; they are thin, transparent, without fringe of papillae; elytral surface smooth except for delicate scattered short papillae and scattered low microtubercles which are mostly confined to the anterior half; elytra rusty-red with white flecks in the region of the elytrophores (in life).

Prostomium bilobed, wider than long, with deep anteromedian notch, with distinct cephalic peaks; anterior third with brown pigment (Fig. 3, *a*). Four eyes rather large, faint, anterior pair about twice as large as posterior pair, lateral in position, in region of greatest prostomial width. Median antenna with short cylindrical brown ceratophore; style about equal in length to prostomial width, cylindrical basally, distal half consisting of slender tip (regenerating?). Lateral antennae with short brown ceratophores inserted ventral to median antenna; styles slightly shorter than prostomial length, subulate, with wider dark basal part and slender tip, with short scattered papillae. Left palp about three times the prostomial length, right one about half as long, probably regenerating; they are smooth, tapering gradually to slender tips. Tentacular segment with elongated, irregularly pigmented basal lobes each with a single seta. Upper pair tentacular cirri longer than the lower pair, slightly longer than prostomial width, darkly pigmented basally and a darker subterminal band, with long slender tip and short papillae. Dorsal cirri with cirrophores bulbous basally, pigmented; styles taper gradually to long slender tips, pigmented on basal third and darker subterminal ring; they extend slightly beyond the neurosetae, the more posterior ones are longer, more slender. Ventral cirri shorter than neuropodia, subulate (Fig. 3, *c*). Anal cirri (left one missing) long, with long slender tip. Segmental papillae begin on segment 6, continuing posteriorly; they are short, cylindrical, extending dorsally between successive neuropodia. The single specimen was massed with eggs.

Parapodia rather long (setae and parapodia about as long as body width); notopodium a rounded lobe tapering to a slender acicular lobe; neuropodium diagonally truncate posteriorly, with a conical acicular lobe anteriorly (Fig. 3, *c*, *d*). Notosetae numerous, forming a spreading bundle, shorter and slightly stouter than neurosetae, 12.5 to 20μ in diameter basally, tapering gradually to short bare blunt to pointed tips, with numerous short spinous rows extending almost to tip; upper notosetae shorter, more arched, with pointed tips (Fig. 3, *e*); rest longer with bluntly worn tips (Fig. 3, *f*). Neurosetae with long stem region, 7.5 to 10μ in diameter basally, with enlarged spinous region (12.5 to 15μ in greatest diameter in basal part), tapering to slender bare hooked tips, all with secondary tooth close to tip (Fig. 3, *h*); upper ones long, more slender (Fig. 3, *g*), lower ones with shorter spinous regions (Fig. 3, *i*).

Locality.—Type (U.S.N.M. no. 26457): Vineyard Sound, Mass., on floating gulfweed, as *Sargassum* and others, September 3, 1953, collected by John Dearborn.

Harmothoë macginitiei, n. sp.

Fig. 4, *a–i*

The species is based on a single specimen found at low tide at Hadley Harbor, Naushon Island in the Woods Hole area, Mass. It was dug under water and found in the sievings of the muddy sand. The species is named for Prof. George MacGinitie.

Measurements.—Length 20 mm, greatest width including setae 8.5 mm, width excluding setae 5.25 mm. Segments 36.

Description.—Body widest in middle two-thirds, tapering gradually anteriorly and posteriorly, greatly flattened dorsoventrally. Body without color. Elytra 15 pairs, large, oval, overlapping, covering the dorsum, tannish, with numerous amber-colored tubercles which gradually get larger posteriorly on each elytron, none of which get to the size of macrotubercles (Fig. 4, *b*; may get up to 144μ in height); tubercles may be pointed, conical and curved, some bifid, and some quatrifid or somewhat irregular; the larger tubercles are in the center of an irregular circular area which is somewhat scalloped around the edge, with papillae emerging from the inner part of the scallop (Fig. 4, *c*, *d*); elytra with a fringe of papillae on the lateral and posterior borders as well as on the elytral surface; tubercles and papillae covered with a good deal of debris.

Prostomium bilobed, wider than long, with a

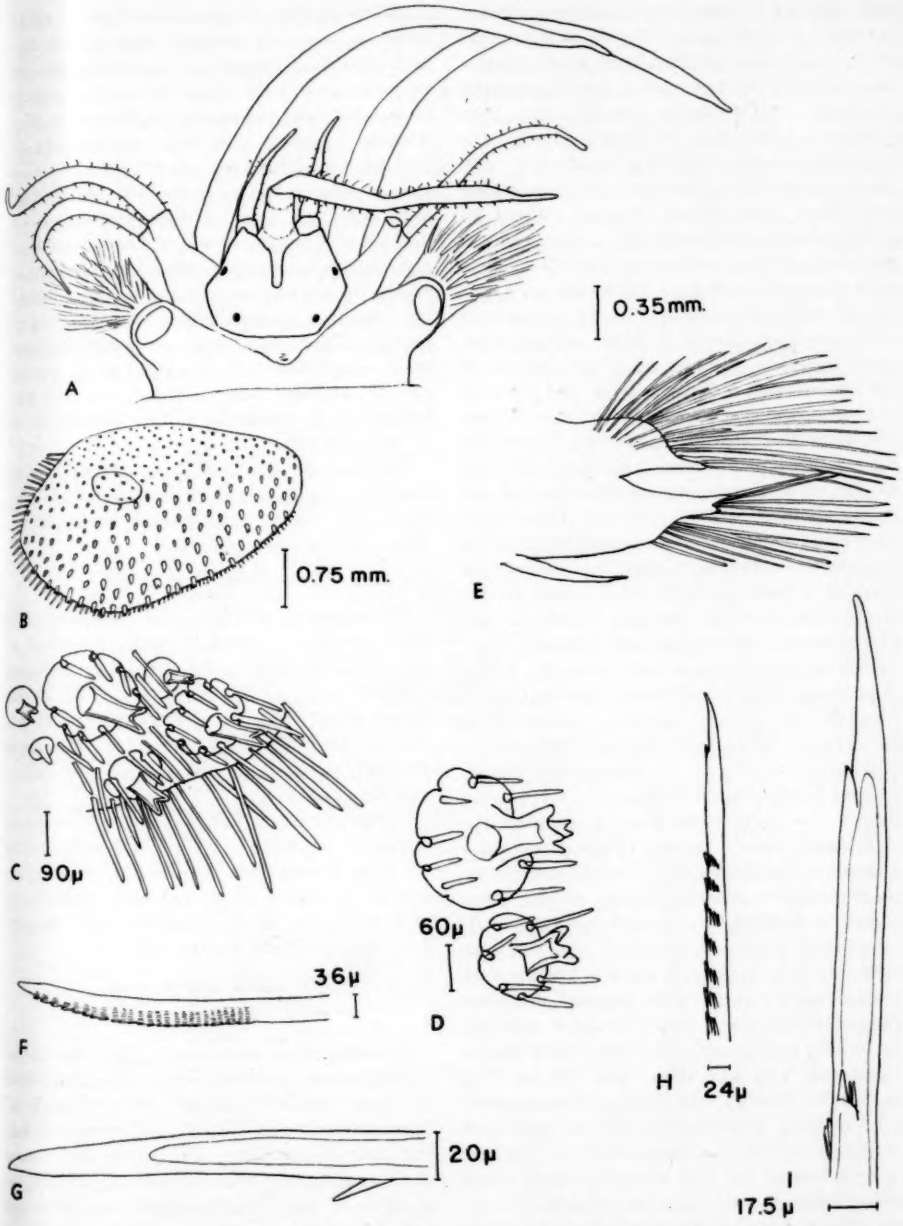


FIG. 4.—*Harmothoë macginitiei*, n. sp.: *a*, Dorsal view prostomium and first two segments (elytra removed, upper right tentacular cirrus missing); *b*, middle right elytron; *c*, portion of elytral border showing tubercles, scalloped circular areas and papillae; *d*, same, showing quatrifid elytral tubercles; *e*, middle left parapodium, anterior view; *f*, upper notoseta; *g*, tip of middle notoseta; *h*, tip of neuroseta; *i*, same, more enlarged.

deep anteromedian notch, with rather indistinct triangular cephalic peaks (Fig. 4, *a*). Four eyes small, anterior pair slightly larger than posterior pair, lateral in position, just anterior to greatest prostomial width. Median antenna with large cylindrical ceratophore; style amost twice the prostomial width, tapering gradually, with slender tip and long papillae. Lateral antennae with short ceratophores inserted ventral to median antenna; styles subulate, papillate, about the length of the prostomium. Palps more than three times the prostomial width, smooth, tapering gradually to slender tips. Tentacular segment with large tentacular basal lobes, without setae; tentacular cirri subequal in length, similar to median antenna; a distinct nuchal fold posterior to prostomium (folded back in Fig. 4, *a*). Dorsal cirri extending slightly beyond the tips of the neurosetae, similar to median antenna, with long slender tip and numerous papillae. Ventral cirri short, subulate, with slender tips (Fig. 4, *e*). Anal cirri missing. Segmental papillae begin on segment 6, continuing posteriorly; they emerge from an inflated rounded lobe ventral to the neuropodia, becoming elongate cylindrical and turned dorsally between successive neuropodia.

Parapodia long (setae and parapodia longer than body width), biramous; notopodium a rounded lobe with a digitiform acicular lobe; neuropodium conical, with a supraacicular slender digitiform lobe (Fig. 4, *e*). Setae golden yellow. Notosetae numerous, forming a very thick bushy bundle, the lower ones about as long as the neurosetae, slightly curved, of about the same diameter as the neurosetae (15 to 36μ in diameter basally); upper notosetae stouter, shorter, more arched, with short bare pointed tips (Fig. 4, *f*); others with longer bare pointed tips—may be very long (Fig. 4, *g*), with traverse spinous rows in which the spines are rather long and prominent (longer than in the typical *Harmothoë imbricata* type); they are covered with a good deal of debris. Neurosetae with long stem region (20 to 27.5μ in diameter basally), with enlarged spinous region (27.5 to 42.5μ in greatest diameter in basal part of spinous region), tapering gradually to long bare slightly hooked tip, with secondary tooth which is large, straight, and rather far removed from the tip (Fig. 4, *h*, *i*; may be lacking in a few lower neurosetae).

Remarks.—*H. macginitiei* resembles *H. areolata* Grube (known from English Channel, Mediterranean, Adriatic) and *H. aculeata* Andrews (known from North and South Carolina, Florida). It differs in that *H. macginitiei* has the elytral tubercles becoming gradually larger posteriorly, none attaining the size of macrotubercles; the tubercles are conical, some bifid, some quatrifid or irregular, the larger ones in the center of an irregular circular area with papillae. In *H. areolata*, the elytra have several rows of conical pointed macrotubercles (none bifid) arising from large polygonal areas, without papillae; in *H. aculeata*, the elytra have 1 to 2 rows of conical macrotubercles (may be bifid) arising from irregular circular areas near the border of which are chitinous microtubercles as well as some papillae. The cephalic peaks are poorly developed in *H. macginitiei*, well developed in *H. areolata* and *H. aculeata*. None of the dorsal cirri were inflated in *H. macginitiei* as they sometimes are in the other two.

Locality.—Type (U.S.N.M. no. 26458): Hadley Harbor, Naushon Island, in the Woods Hole area, Mass., low water, muddy-sand, September 2, 1952, M. Pettibone, collector.

Genus **Hartmania**[2], n. gen.

Prostomium harmothoid, with distinct cephalic peaks and lateral antennae inserted ventral to the median antenna. Elytra 15 pairs, on segments 2, 4, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 26, 29, 32. Elytra large, cover the dorsum. Segments less than 40. Both noto- and neurosetae subequal in diameter, ending in slender pointed to capillary tips, not hooked.

Hartmania resembles *Enipo* and *Nemidia* as defined by Malmgren, 1865; it differs in having less than 40 segments, with elytra covering the dorsum. It differs from *Arcteobia* Annenkova, 1937, in having all the neurosetae with slender sharp tips, none with hooked bifid ones.

Hartmania moorei, n. sp.

Fig. 5, *a–e*

Five specimens were found in the burrows of large specimens of *Nereis virens* in the sandy-mud of Little Harbor, Newcastle, New Hampshire. They are small (up to 15 mm), rather fast moving, and easily escape notice. The species shows some of the adaptations of a commensal polynoid, as small eyes and smooth elytra; it lacks the melanistic body pigmentation as is found in some. Two specimens were found among the material dredged in the region of Cape Cod, Mass., by the U. S. Fish Commission and reserved for study by

[2] Named for Dr. Olga Hartman, who has contributed so much to the study of the polychaetes.

A. E. Verrill. The species is named for Dr. George M. Moore, who collected the majority of the specimens by persistent digging.

Measurements.—Length 8.7 to 15 mm, greatest width excluding setae 2.5 to 3.6 mm, width including setae 3.7 to 5.2 mm. Segments 35–37.

Description.—Body of nearly uniform width in middle third, tapering slightly anteriorly and posteriorly, flattened dorsoventrally. Body without color. Elytra 15 pairs, rather large, imbricated, cover the dorsum, oval to subreniform in shape, smooth, lacking papillae and tubercles, with pale to light rusty-brown, crescent-shaped colored areas on medial halves of elytra (Fig. 5, *a*; in life and in alcohol).

Prostomium bilobed, wider than long, with a deep anteromedian notch, with distinct blunt cephalic peaks (Fig. 5, *a*). Four eyes small, anterior pair lateral in position, just anterior to greatest prostomial width. Median antenna with bulbous ceratophore; style about equal in length to prostomial width, tapering to slender, slightly bulbous tip and with short scattered papillae. Lateral antennae inserted ventral to median antenna on prostomium; short ceratophores hidden by the bulbous ceratophore of median antenna; styles short—less than half the length of the median antenna, tapering to slightly bulbous tips. Palps up to two and a half times the length of the prostomium, with numerous

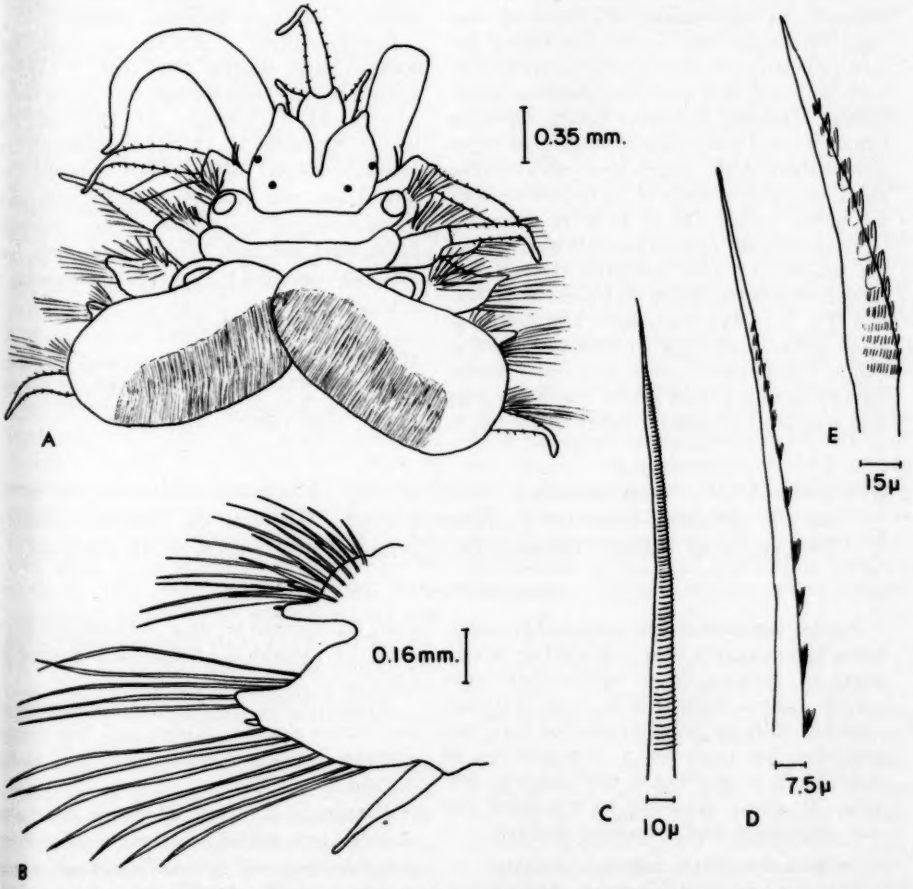


FIG. 5.—*Hartmania moorei*, n. sp.: *a*, Dorsal view prostomium and first 6 segments (first two pairs elytra removed); *b*, thirteenth right parapodium, anterior view; *c*, notoseta; *d*, tip of supraacicular neuroseta; *e*, subacicular neuroseta.

close-set short claviform papillae. Tentacular segment with basal lobes elongated, each with 2 or 3 dark setae; two pairs of subequal tentacular cirri similar to median antenna. Dorsal cirri with bulbous cirrophores; styles extend to about the tips of the neurosetae, tapering gradually distally to slender slightly bulbous tips, with short scattered claviform papillae. Ventral cirri shorter than neuropodia, subulate, with slightly bulbous tips and few short globular papillae (Fig. 5, *b*). Pair of long anal cirri—the longest appendages of the body. Segmental papillae short, globular, inconspicuous, begin on segment 6, continuing posteriorly.

Parapodia biramous, long, slender—parapodia including setae longer than body width; notopodium a short rounded lobe with projecting finger-like acicular lobe; neuropodium conical, the apex forming a short supraacicular lobe (Fig. 5, *b*). Both notosetae and neurosetae delicate, transparent, iridescent. Notosetae form a spreading bundle of 5 or 6 rows of graded lengths, the upper row the shortest, the longest lower row extending about one-half the length of the neurosetae; they are widest basally (10 to 12.5μ in diameter), tapering gradually to short capillary tips, appearing smooth but with numerous close-set fine spinous rows as seen under the highest magnification (Fig. 5, *c*). Few notosetae of tentacular segment rather stout (20μ in diameter), lacking slender tips; upper notosetae of second or buccal segment curved, without slender tips. Neurosetae with long shaft of uniform width (10 to 15μ in diameter basally), with enlarged distal spinous regions (15 to 20μ in greatest diameter on basal part of spinous regions), gently curved, ending in short slender tips (not capillary); supraacicular neurosetae with longer spinous regions and longer more slender tips (Fig. 5, *d*); more ventral neurosetae with shorter spinous regions (Fig. 5, *e*). Two specimens (collected November 8, 1954, New Hampshire) were filled with eggs. In life, the red ventral nerve cord and cerebral ganglion in the prostomium show conspicuously through the delicate transparent tissues of the body.

Remarks.—The setal, parapodial and prostomial shapes resemble those figured by Malmgren (1865, pl. 13, fig. 22) for *Nemidia torelli*. It differs by having eyes present, fewer number of segments, and more numerous notosetae.

Locality.—Types (U.S.N.M. nos. 26462 and 26463): Little Harbor, Newcastle, N. H., in sandy-mud burrows associated with *Nereis virens*, July 4, 1953 (1 specimen, M. Pettibone, collector); November 11, 1954 (4 specimens, G. M. Moore, collector). Also mouth of Cape Cod Bay, Mass., near Race Point Light, gray mud, 26 fathoms, 1879, Loc. 296; near Cuttyhunk Light, sand and mud, 17½ fathoms, 1880, Loc. 860—both collected by U.S. Fish Commission.

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MAMMALOGY.—*Descriptions of pocket gophers* (Thomomys bottae) *from northeastern Arizona.*

DONALD F. HOFFMEISTER, Museum of Natural History, University of Illinois, Urbana, Ill. (Communicated by David H. Johnson.)

(Received February 11, 1955)

Pocket gophers of the species *Thomomys bottae* have recently been collected in certain parts of Arizona from which they were poorly known before. This new material, together with previously collected material, indicates the need for a re-evaluation of some kinds of gophers in northeastern Arizona. It seems desirable to recognize one new subspecies and redescribe another.

Thomomys bottae rufidulus, n. subsp.

Type.—Adult male, no. 7344, Univ. Illinois Mus. Nat. Hist., from 2 miles east of Joseph City, Navajo County, Ariz.; collected January 1, 1953, by Donald F. Hoffmeister, original no. 1965.

Range.—Along parts of the Little Colorado and Puerco rivers in Arizona and New Mexico; probably between Winslow, Ariz., and Gallup, N. Mex.

Diagnosis.—A race of *Thomomys bottae* characterized by a reddish color intermixed with considerable black and by small size. Color in summer: back (*a*) Clay-Color or Cinnamon approaching Cinnamon-Buff (capitalized color terms from

Ridgway, *Color standards and color nomenclature*, 1912), with numerous dark hairs forming a dark stripe down back, with color paling on sides to Cinnamon-Buff; underparts whitish with a heavy wash of Pinkish Cinnamon, which is heaviest along midventral line and fading out toward lateral line. Color in winter: sides (*j*)14′ Ochraceous-Tawny, with color on back interspersed with brown, giving dorsum a grayish appearance; underparts whitish with only the faintest indication of wash of Cinnamon. Size: small; smaller than *T. b. aureus* and *T. b. peramplus* by about seven to ten per cent; about the same size or slightly smaller than *T. b. fulvus*. Skull: small in most features but broad interorbitally.

Comparisons.—*Thomomys bottae rufidulus* differs from *T. b. aureus* in being less bright red, more blackish, and in smaller size. It differs from *T. b. peramplus* in being lighter in color, with a less prominent dark stripe down the back. *T. b. rufidulus* differs from *T. b. fulvus* in lighter, more reddish upper parts, lighter underparts, and shorter hind foot.

Measurements.—Four adult males and two adult females, all topotypes, give the following respective measurements: total length, 225, 213, 226, 226, 229, 216; tail, 63, 62, 66, 70, 77, 66; hind foot, 33, 31, 31, 34, 31, 32; ear, 6, 6, —, 7, 6, 6; basilar length, 34.7, 32.5, 34.9, 34.9, 34.3, 32.7; zygomatic breadth, 24.6, 22.0, 23.8, 23.6, 23.8, 22.7; mastoidal breadth, 21.1, 20.5, 20.8, 20.8, 20.1, 19.9; length of nasals, 13.7, 12.3, 13.6, 13.7, 13.6, 13.0; least interorbital breadth, 7.1, 6.8, 7.0, 6.7, 6.9, 6.7; length of diastema, 13.7, 12.4, 14.1, 13.8, 13.4, 12.9; length of rostrum (taken from middle of anterior border of nasals to maxilla at its lateralmost point of union with hamular process of lacrimal), 17.0, 15.6, 16.8, 17.0, 16.5, 15.8; breadth of rostrum (taken where maxillary and premaxillary bones meet on sides of rostrum), 8.3, 7.9, 8.3, 8.3, 8.0, 7.9; palatilar length (exclusive of palatal spine), 23.3, 21.4, 23.8, 23.8, 23.2, 22.0. In each instance, the measurement for the type specimen is given first.

Remarks.—*T. b. rufidulus* resembles most closely in morphological features *T. b. aureus* and *T. b. fulvus*. However, *rufidulus* is readily distinguishable from these two. This subspecies has a position somewhat intermediate between the pale-colored "*aureus*" gophers of northeastern Arizona and the dark-colored "*fulvus*" gophers of the Mogollon Plateau. In his revision of the pocket gophers of Arizona, Goldman (North Amer. Fauna **59:** 14. 1947) was unaware that such a race might exist.

The name *rufidulus*, meaning somewhat reddish or a little reddish, is in allusion to both the Little Colorado (= reddish) River and to the somewhat reddish coloration of the gophers.

Specimens examined.—**Arizona:** *Navajo County:* 2 miles east of Joseph City, 8 (Univ. Illinois, Mus. Nat. Hist.). *Apache County:* Navajo, 1 (Univ. Illinois, Mus. Nat. Hist.). **New Mexico:** *McKinley County:* Gallup, 2 (U. S. Biol. Surv. Coll.).

STATUS OF *Thomomys latirostris* MERRIAM

In 1901, Merriam described the pocket gopher *Thomomys latirostris* from Little Colorado River, Painted Desert, Ariz. (Proc. Biol. Soc. Washington **14:** 107. 1901). In 1947, Goldman restricted the type locality to Tanner Crossing, about 3 miles above Cameron (North Amer. Fauna **59:** 11. 1947). Merriam had but a single specimen from the Painted Desert, and the skull of this animal was unique in having an exceedingly broad rostrum. Attempts by Goldman to obtain additional specimens from the vicinity of the type locality proved unsuccessful, and he regarded the skull of the type as abnormal, calling Merriam's *latirostris* an aberrant individual of the race *Thomomys bottae aureus*. During the past few years, we have been successful in catching three gophers near Cameron. These specimens indicate that the gophers from near Cameron are quite distinct from other races of *T. bottae*, and gophers from along the western edge of the Painted Desert may differ in the same way. However these specimens do indicate that the rostrum of the type specimen is atypical. This gopher may be characterized as follows:

Thomomys bottae latirostris Merriam

Type.—Adult male, no. 18003/24914, U. S. Biol. Surv. Coll., from Little Colorado River, Painted Desert (= Tanner Crossing), Coconino County, Ariz.; collected September 22, 1899, by C. H. Merriam and V. Bailey, original no. 504.

Range.—Known only from Tanner Crossing and 4½ to 5 miles north of Cameron, Ariz.; probably in much of the Painted Desert.

Diagnosis.—A race of *Thomomys bottae* characterized by pale coloration and small size. Color on back and sides near (*e*) Orange-Buff or Pale

Yellow-Orange; tail and feet whitish; underparts whitish, with plumbeous underfur showing. Size small; smaller than typical *T. b. aureus;* rostrum long and broad (but condition in type specimen is atypical), relatively larger than that of *T. b. aureus.*

Comparisons.—*Thomomys bottae latirostris* needs close comparison only with *T. b. aureus,* from which it differs in paler color (Pale Yellow-Orange rather than Cinnamon-Buff) and in a smaller skull with a relatively broader rostrum.

Measurements.—Three males, two adults and one subadult, from 4½ to 5 miles N Cameron give the following respective measurements: total length, 212, 226, 206; tail, 61, 74, 60; hind foot, 32, 30, 30; ear, 5, 5, 5; basilar length, 33.0, 32.7, 31.7; zygomatic breadth, 23.1, 23.3, 20.9; mastoidal breadth, 19.7, 19.7, 19.6; length of nasals, 15.1, 12.6, 12.7; least interorbital breadth, 7.1, 6.6, 6.9; length of diastema, 12.9, 12.6, 11.2; length of rostrum, 17.3, 15.4, 15.4; breadth of rostrum, 8.6, 8.1, 8.2; palatilar length (exclusive of palatal spine), 21.2, 21.0, 20.5.

Remarks.—Goldman (*op. cit.*) considers the type locality of Tanner Crossing as about three miles above Cameron. However, Barnes in his *Arizona place names* (Univ. Arizona Bull. **6**: 437. 1935) says this crossing of the Little Colorado was near the Cameron bridge, and thus at Cameron itself.

One specimen (no. 161183, U. S. Biol. Surv. Coll.) from Tuba City, Coconino County, Ariz., closely approaches specimens of *latirostris* from near Cameron. Additional material from Tuba City may indicate that specimens from there are referable to *T. b. latirostris.*

Specimens examined.—**Arizona:** *Coconino County:* 5 miles north of Cameron, 1 (Univ. Illinois, Mus. Nat. Hist.); 4½ miles north of Cameron, 2 (Univ. Illinois, Mus. Nat. Hist.); Little Colorado River, Painted Desert, 1 (type, U. S. Biol. Surv. Coll.).

MALACOLOGY.—*Shell structure of West American Pelecypoda.* JOHN J. OBERLING,[1] University of California. (Communicated by Harald A. Rehder.)

(Received February 17, 1955)

From an examination of numerous specimens from the major pelecypod families, it appears that the shells are composed of two types of deposits. One is secreted by the general surface of the mantle and is here termed palliostracum; the other is secreted over the muscle attachment areas and is here termed myostracum.

The palliostracum is composed, in addition to the periostracum, of three major layers, the ectostracum, mesostracum, and endostracum (Fig. 1). The ectostracum forms the outer surface of the shell, including the margins. The mesostracum emerges on the inner surface outside the pallial line and includes the hinge. The endostracum forms the inner surface within the pallial line. A seemingly two-layered shell may result from combination of the outer two (mesectostracum) or inner two (mesendostracum) major layers. Sometimes all three layers are structurally identical, as in *Lyropecten.*

The myostracum is divisible into several components, the most important of which are: the pallial myostracum, a thin deposit secreted at the pallial line and the adductor myostraca, similar deposits secreted in the scars of the adductor muscles. Additional myostracal deposits are formed in the scars of lesser muscles, such as the retractor pedis.

The terms hypostracum and ostracum, hitherto employed in the nomenclature of the shell layers of pelecypods, have been discarded, for they refer to a "two-layered shell." Moreover, although Thiele (1903), the originator of the terms generally used the term hypostracum for the "inner layer" and ostracum for the "outer layer," subsequent authors (Jameson, 1912; Coker et al.,

[1] Contribution from Museum of Paleontology, University of California.

The writer gratefully acknowledges advice and criticism from J. Wyatt Durham, R. L. Langenheim, Jr., and Howel Williams. He is also grateful for help and advice from Zach Arnold in many technical and other problems, and from W. K. Emerson in bibliographic and other matters. Dr. Durham kindly made available the vast collections of the Museum of Paleontology of the University of California at Berkeley. Miss Joan Sischo drafted the drawings. Grateful acknowledgment is made to the California Research Corporation for financial support of these investigations.

1919; Gutsell, 1930; Newell, 1937) have used these terms with different connotations, usually referring the hypostracum to the adductor myostracum, so that the status of the terms is now very uncertain.

The pelecypods examined may be arranged into three major groups according to shell structure. These groups are:

1. The nacroprismatic group. Primitive pelecypods typically with a nacreous mesendostracum and a prismatic ectostracum.
2. The foliated group. Pelecypods typically with one or more foliated layers.
3. The complex-lamellar group. Pelecypods typically with a complex endostracum and a crossed-lamellar mesectostracum.

The nacroprismatic group includes the anisomyarians (except the Dreissenidae), the Nuculacea, Unionacea, Trigoniidae. Periplomatidae, Pandoridae and Lyonsiidae. The foliated group includes the monomyarians. The complex-lamellar group includes the heterodonts, the Arcacea and the Dreissenidae.

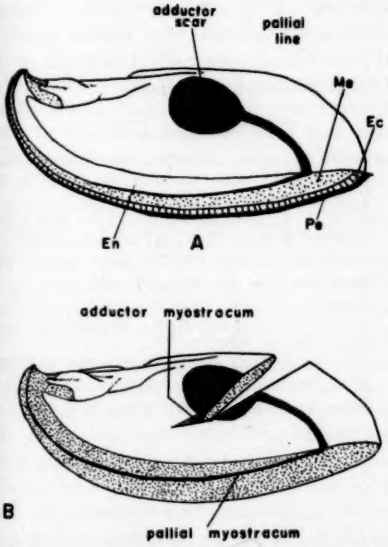

FIG. 1.—*a*, Longitudinal section and inner surface of a pelecypod valve showing positional relationship of palliostracal layers to each other, as well as to the pallial line and adductor scar; *b*, longitudinal and oblique sections and inner surface of a pelecypod valve showing pallial and adductor myostraca. Palliostracum stippled. (In this figure and in Fig. 2, Ec = ectostracum; En = endostracum; Me = mesostracum; Pe = periostracum.)

The structure of the various families and genera in each group may show various modifications from the typical structure of the group.

The shells of certain pelecypods are markedly tubulate. The distribution of the tubules and at times their general aspect and density vary greatly between families or superfamilies but are generally relatively constant within such groups.

The distribution of the tubules in some families of pelecypods follows (Fig. 2):

Tubules in the endostracum only—Chamidae, Lucinidae, most Mytilidae.

Tubules in the endostracum and mesostracum —Carditidae, Lyonsidae.

Tubules apparently present in all three layers—Spondylidae.

Tubules originating only in the area surrounded by the pallial line but penetrating all three layers—Arcacea.

In the first three cases the tubules must have originated at the same time as the surrounding shell substance, while in the last case the portion of the tubules within the mesectostracum was formed, probably by resorption, after deposition of the surrounding shell substance. The tubules formed together with the shell substance are more or less perpendicular to the growth planes in that substance. Tubules resulting from resorbtion do not, however, show a constant relationship to the growth planes, but tend to be perpendicular to the base of the layer or set of layers into which they have been intruded.

Tubules have been observed in association with all types of shell structures except the granular and homogeneous. The prismatic structure seems to be the only one where there is a regular relationship between the position of the tubules and the structural elements. In some forms, the tubules occur mostly between the prisms, in others within the prisms, but they have never been observed to occur at random both within and without these structural elements.

The structural elements in the pelecypod shell may be variously related positionally to the shell surfaces and the growth lines.

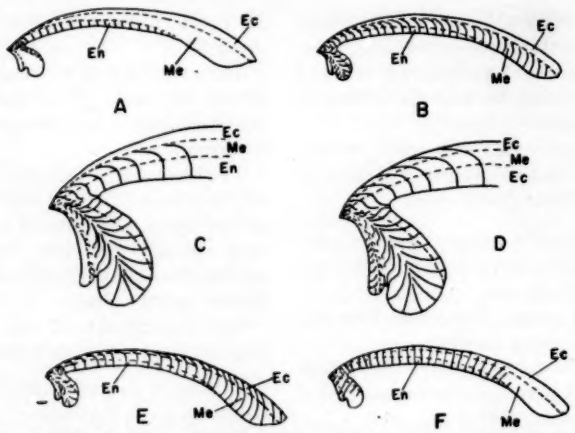

FIG. 2.—*a*, Longitudinal section of a pelecypod valve, showing endostracal tubules; *b*, same as above, showing mesendostracal tubules; *c*, distribution of tubules as in *b*, showing in detail the tubulation pattern in the apical region; *d*, longitudinal section of the apical region, tubules occurring in all three layers; *e*, longitudinal section through the whole valve, showing tubules occurring in all three layers; *f*, longitudinal section of a pelecypod, tubules in all three layers but appearing only within pallial line.

They may be vertical (perpendicular to the outer surface), horizontal, or oblique in all possible directions, or they may even be spirally arranged like the folia in many foliated pelecypods. In the pectinids, for example, where most genera show some degree of spiraling of the folia, the spirals are twisted clockwise in some genera, counterclockwise in others.

The classification of ribbing and related structures employed here is based in part on morphology and in part on genesis, and is as follows:

1. Nonadditive ribbing, produced by deformations of the mantle margin, either plications or lobations, or both.

2. Additive ribbing, featuring mainly relatively rapid secretion on limited areas of the shell.

3. Composite ribbing, formed by components of both the previous types, with a non-additive framework on which are secreted additive structures, whose position is directly related to and in most cases apparently determined by that of the nonadditive components.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

At the meeting of the Philosophical Society held in the auditorium of the Cosmos Club on May 7, 1954, the following paper was read by Dr. H. L. CURTIS:

Mr. President, members of the Philosophical Society of Washington, and guests:

It gives me pleasure to present to you a paper, requested by the Communications Committee, on the development in Washington of a sub species of the genus, "*Homo sapiens scientifica*," the members of which no longer adorn themselves by wearing "tails". This metamorphosis has taken place in the last few generations of scientists: in fact I believe it has largely taken place during my membership in the Society.

This is not the first time that there has been a decided change in the physical appearance of the men whom this Society has honored by choosing them for its presidents. If you will consult the Journal of the Washington Academy of Sciences for August 1930 you will find the pictures of most of the Presidents from Joseph Henry, 1871, to W. D. Lambert, 1930. You will notice that the early presidents wore, for the most part, full beards. Then came a short time when a president had a choice concerning his beard. But soon it was not customary to have even a vestige of hirsute adornment.

But to go back to the tails. When I joined the Society in 1908 all possible formalities were strictly observed. At the opening of this address, the president and I tried to give you a sample of the proper behavior at the introduction of a speaker at that time. At every meeting, the presiding officer and each speaker wore formal dress, which at that time consisted of a stiff front, white shirt with studs, a white bow tie and a broadcloth coat with tails. Shoes optional, but patent leather with buttons preferred. Also those members who were generally recognized as the intellectual giants of the Society usually came to the meetings, then held in the Dolly Madison house, in formal dress and occupied large chairs, fully upholstered in leather, which formed the first two rows of seats (eight chairs). Younger members, in business dress, occupied ordinary chairs behind the Giants. I remember only one outstanding paper of my first year. It was by Simon Newcomb on the composition of the polar caps on Mars. He assured the audience that they must consist of carbon dioxide snow, an hypothesis which is not now universally accepted. I also have two other reasons for remembering Simon Newcomb. He signed in 1909 my certificate of membership in this Society; a scroll about the size of a high school diploma which I have seen recently, but which is now hiding among the accumulation of 50 years of mementos. He died while President of the Society a few months after I had been admitted.

Incidentally I learned by the gossip of that day that Newcomb's death relieved the Society of an embarrassment. Some years before Mr. Wead of the Patent Office was elected fifth vice-president. He was gradually promoted along the vice-presidential row where he performed his duties very acceptably. But to be President of his honorable Society, in which office he would be expected to deliver a presidential address covering some of his contributions to science, that was an office according to some Society members which should be reserved for learned men; and such men were not available in the Patent Office. He was first vice-president when Newcomb died, so according to the by-laws became president. Since this was an act of God, and not of the Society, all cause for friction was swept away. I remember something of his address which is more than I can say of many presidential addresses.

In order of proceeding at a regular meeting was, in 1909, much as it is now. First was the reading of the minutes of the last meeting and their correction. In 1909, and for a short time thereafter, they were written in long-hand in a permanently bound medium-sized notebook. Particular attention was given to the discussions. I have been told that some members insisted on this detail because they might want to use the facts revealed in the discussion to establish priority claims in patent litigation. Following the regular program, an opportunity was given for informal communications, provided there was time before the adjournment hour of 10 p.m.

But the real social event of each year was the annual meeting for the reading of reports and election of officers. Then everyone who could make the grade appeared in tails. Discretion was

thrown to the winds. Whereas in regular meetings smoking was frowned upon, at the annual meeting cigars were provided. No nominations for the various offices were made. The ballots were cast, and, while the tellers were counting the votes, the members smoked and visited. Almost always several ballots were required for electing a president. Usually it was a "free for all" 'til someone got a majority. After that, voting produced results more rapidly. But there were elected five vice-presidents, two secretaries, a treasurer and several members-at-large of the General Committee, so adjournment was seldom much before the 10 o'clock dead-line.

Before going to more recent changes, I wish to mention a custom which goes back to the very early days of the Society. That custom is that the presiding officer shall address the speaker only as Mr. "So & So," using no titles. This custom, according to tradition, was started by General Sherman, an active member in the early days, who was of the opinion that discussion of scientific subjects would proceed more freely if each participant was not reminded of his rank in the mundane world. I have found this a very useful custom. I have often wondered how this will be modified when our lady members present papers.

About 1910, the Cosmos Club started a building program which temporarily required a new meeting place. I recall that at one time the meetings were held at the Auditorium of the Carnegie Institution Building at P Street and Connecticut Avenue. Under these conditions and with the impact of World War I, formalities were appreciably relaxed. About this time the tuxedo made its appearance and soon became very popular. A tuxedo is defined in one dictionary as "a tailless dinner jacket." Of course, there was an interval when the presiding officer could wear tails or be tailless. But long before World War II, tails had vanished from the scientific world of Washington. But the tuxedo still persists.

The change in dress of the speakers has proceeded more rapidly—by World War II it was not unusual for a speaker to appear in a business suit. Now it is almost universal.

Another change in dress has occurred in connection with the dinners given in honor of the speaker at the Joseph Henry Lecture. At first, these dinners were very formal. Those invited included only officers and past presidents. At the first dinner in 1931 I think there was no outfit lower than a tux. Of course these were worn at the meeting which followed, lending a more formal appearance to the audience than at regular meetings. This custom was continued for some time. During World War II the past presidents were, for good reason, dropped from the invitation lists. This year they were again included, but evidently the moths had played havoc with the tuxedos of the past presidents. But if you are a prospective president, you better be making arrangements with a renting agency, though a clause in your contract should cover the case of changing styles. Tails may come back.

Another innovation in my day has been the serving of refreshments after meetings. In 1908 there was little sociability among members. As soon as 10 p.m. arrived, everyone filed demurely out of the room, often without a greeting to anyone. Then someone suggested that light refreshments might aid in getting members acquainted. At first they were served only once a month, or once every two months. The improvement in attendance soon convinced the officers that refreshments at every meeting are desirable.

My assignment covered only the non-scientific features of the Philosophical Society. Unfortunately, I could find very little source material, so that I have had to depend largely on my memory. I have checked with some of the older members, and have retained only that which is generally acceptable.

One fact that came to me quite unexpectedly while preparing this address was the length of my membership in the Society. I have been a member of the Philosophical Society of Washington for more than half of its existence. For a few years after I joined the Society there was one member, Past President W. H. Dall, of the Smithsonian Institution, who was one of the founders of the Society. I once talked with him about the first meeting. It was in a reception room of the Smithsonian Building. He was just one of the boys invited to fill up the chairs.

My association with members of this Society continues to be a source of inspiration to me and a pleasure that is heightened with the years.